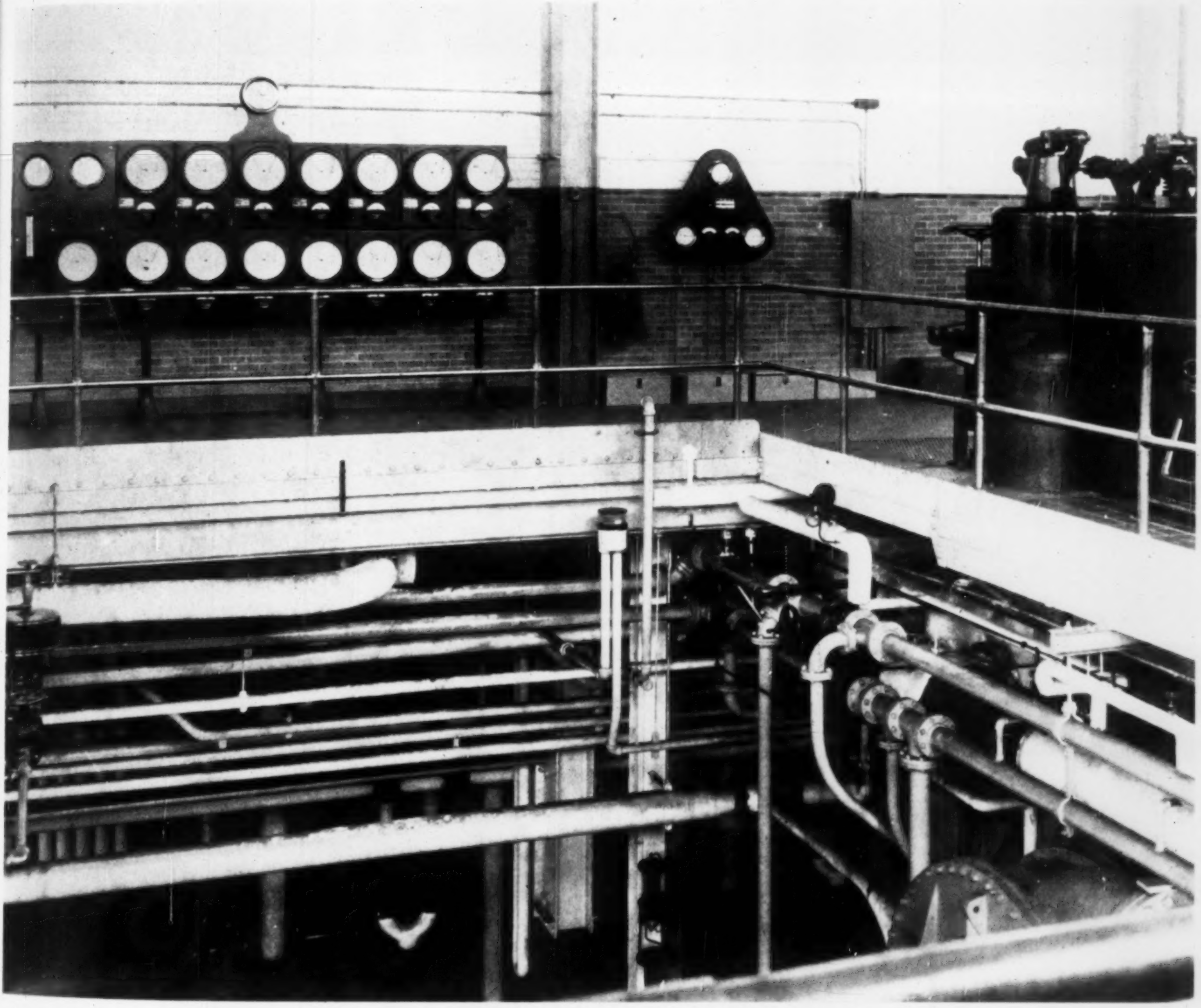
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 5 OCTOBER, 1932 NUMBER 10



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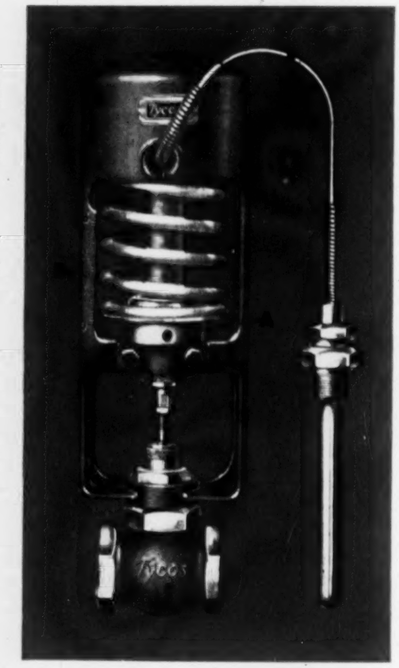

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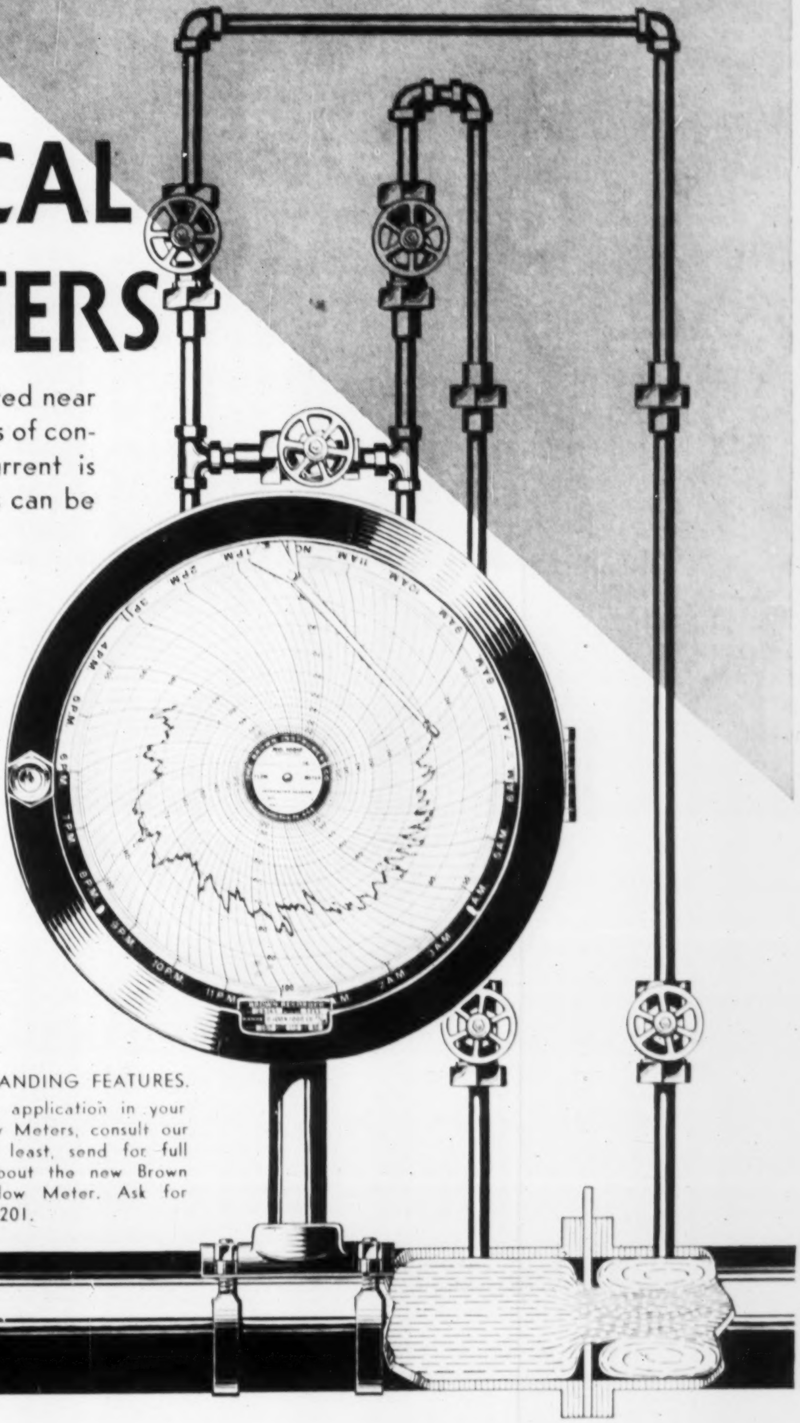

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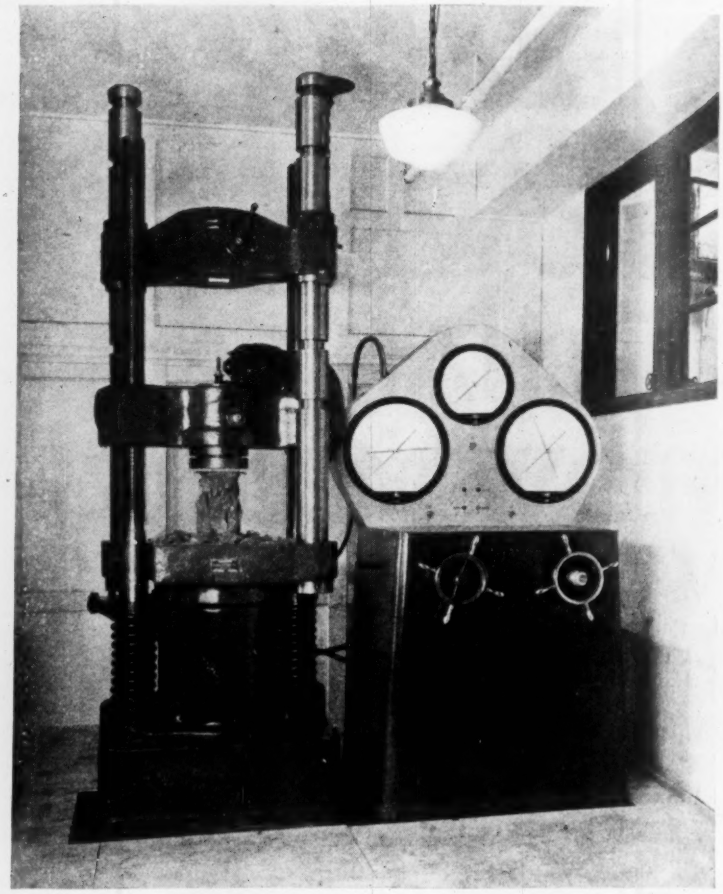

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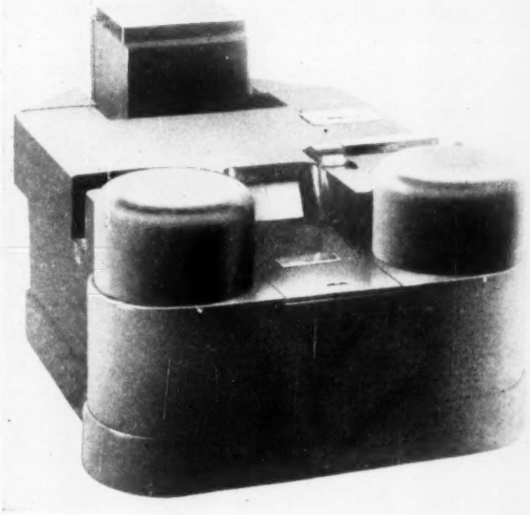

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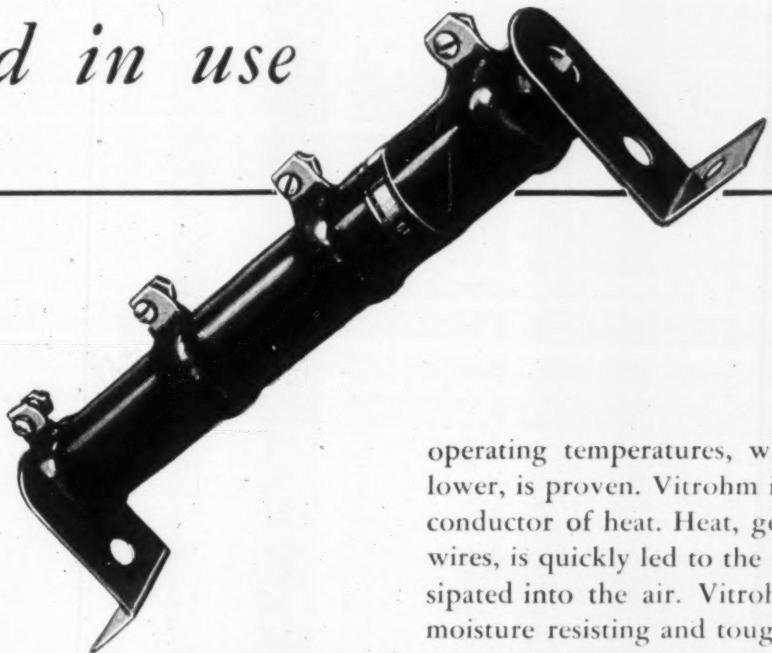
Higher temperatures are employed in manufacture . . . . *than are ever reached in use*



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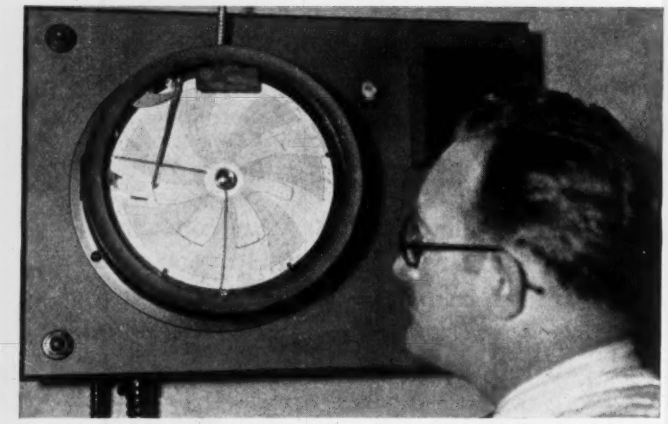

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EDITORIAL COMMENT

In This Issue

◆ One of the newest fields of instrumental measurement, the value of which has been suddenly "discovered" by others than instrument men, is **illuminometry.** Public health services, municipalities, educators, and of course industrial executives, are showing keen interest in the quantitative measurement of both natural and artificial lighting. A by-product of this interest is closer attention to insuring that substitutes for daylight will be turned on and off unfailingly. Mr. Lamb discusses the various angles of this question in a most timely article.

◆ Having described in previous instalments the essential parts of **The Engine Indicator,** Prof. DeJuhasz now begins a detailed treatment of special indicators, both American and European. Many readers will find in this and in next month's instalments the very indicators they have been looking for.

◆ The second instalment of our engineering editor's chapter on **Current Meters** is mainly made up of expertly selected extracts from recent technical papers, letters to technical journals, etc., bringing out characteristics of various types designed for gaging streams, turbine races, etc.

◆ Striking evidence of a recent quickening of interest in **flow measurement and control** is given by the simultaneous appearance of several new meters on the market, as will be seen in the **New Instruments section.**

◆ ◆ ◆

The Front Cover

◆ Last January our front cover showed the elaborate control board of a public utility power plant. We have since then received photographs showing handsome instrument installations in private power plants. Here is one.

Stay in the Pink to Keep Out of the Red

IN HIS radio address on Industrial Rehabilitation, September 24, Board Chairman Robertson, of Westinghouse, stressed the urgent need of putting America's manufacturing facilities on a production basis without further delay. It is reasonable to suppose that the present fierceness of competition will continue to prevail for many months in some industries, for years in others, so that in each of the races for supremacy, victory will be won by the company whose plant is best manned, best equipped, best tooled up and best instrumented.

It is not a sprint that will be entered by the competing plants in each industry: on the contrary it is a long marathon. None but the healthiest stand a chance of being "in the money."

There are two distinct ways in which instruments contribute to the racing ability of industrial plants about to toe the starting line. One pertains to speed; the other to endurance.

The former way is obvious. It is what is now coming to be understood by the world Instrumentation—"measurement and control of processing and working conditions, of physical and chemical properties, of physical and chemical composition, etc., in order to achieve labor saving, fuel saving, increased production of better and more uniform products, minimizing reliance on human watchfulness and preventing accidents."*

The other way in which instruments contribute to a plant's fitness—that pertaining to endurance—may be likened to the general precautions quietly and continuously taken by an athlete to keep himself in the pink.

It is said that family physicians in ancient China received periodical fees from their patients but only while the latter enjoyed perfect health. We read also that today kings, presidents, governors and other eminent men have personal physicians to keep them well. The Life Extension Institute and other organizations remind all of us of the truism that the best health insurance is prevention of disease. Frequent examination of the bodily machine is an essential. "See your dentist at least twice a year." Sound advice. Also, your oculist once a year and, as circumstances warrant, ear, throat, heart, diet, and other specialists—*before* trouble starts.

This, then, is the aspect of measurement and control which we desire to stress—the *continuous health survey,* by which we mean the periodical inspection of every piece of equipment, from the buildings and boilers to such apparently trifling items as lock-nuts, floor-truck castors, etc. For many of these items, visual inspections suffice, but the growing tendency to make each inspection a measurement—to substitute quantitative for qualitative methods—is parallelled by an interesting development in the field of testing instruments. For example the analysis of boiler feed water as well as of condensate is becoming a universal practice and at the same time is being made easier by various new instruments, so that corrosion of steam-generating equipment is on the wane—a case of better health resulting from disease prevention through continuous surveys.

There is only one road to continual operation and great efficiency—the continuous plant survey. For the industrial plant is an organism which functions by the combined operation of many machines, of much equipment. To keep the entire plant operating at its best, each machine and every piece of equipment in the plant must be kept up to scratch at all times. Measurement, testing, and inspection on every part of the plant equipment must be made not "when there is nothing else to do," or when a breakdown occurs, but regularly, continuously, over the entire plant.

Eternal vigilance is the price of keeping plants efficient. And eternal vigilance in a plant means regular, continuous plant surveys.

---

*The Manual of Instrumentation, Part One, "Fundamentals."

"Free Electricity While the Sun Shines"

How Photronic Cells are Employed to Measure Daylight, Operate Beacons, Etc.

By ANTHONY H. LAMB*

IN SPITE of intermittent obscuration by clouds at most stations, more measurements were successfully made during the solar eclipse of August 31, 1932, than in the course of other total eclipses in recent years. Among the data which previously had not been obtained satisfactorily, were numerous accurate minute-by-minute records of the natural illumination at stations both in and out of the zone of totality. Of interest to readers of *Instruments* is the fact that such measurements were made without difficulty—in many cases by men without scientific laboratory training—by means of commercial devices recently reported in the "New Instruments" section.

This is because measurement of natural outdoor illumination by means of either a direct-reading portable indicating instrument, or a recorder, has been simplified to the extent that standard instruments, of suitable calibration, are operated directly by the output of the "Photronic" cell.† A newcomer in the photoelectric field, this is the first cell offering characteristics which make it almost ideally suitable for light measuring problems. It converts luminous energy directly into electrical energy in sufficient quantity to operate indicators, recorders and relays directly, whence the title of this article. It has a negligible temperature coefficient, it is of simple construction and its life will probably exceed that of any photocell so far produced.

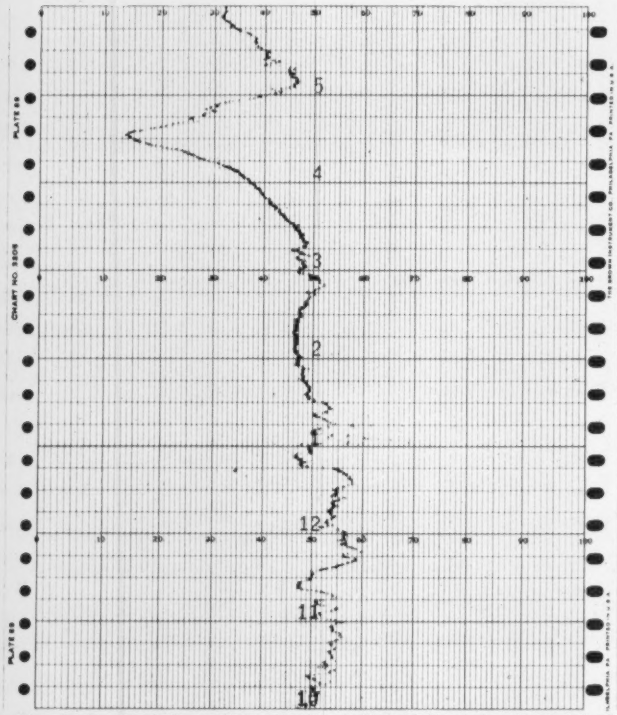

Fig. 1. Record of the sunlight intensity at Philadelphia during the period of the eclipse. Note the "valley" between 3:30 and 5 p. m. (Courtesy Brown Instrument Company)

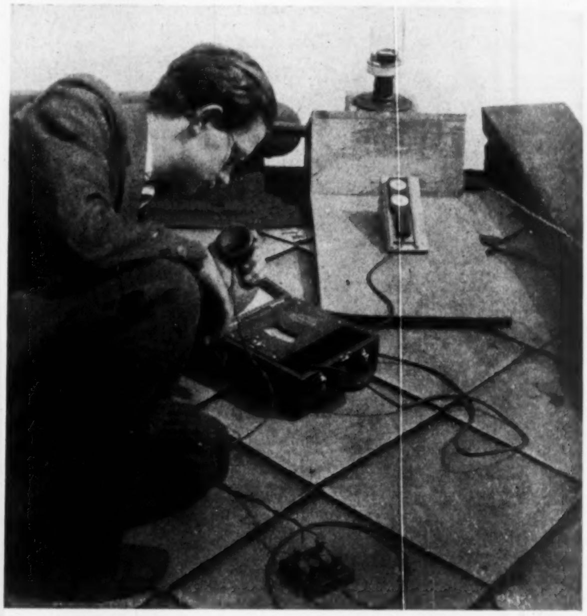

Fig. 2. Checking Sunlight Recorder by 'Phoning Actual Sunlight Readings to Indoor Laboratory.

Portable Apparatus to Measure Sunlight

A portable Sunlight Meter consisting of a "photronic" cell directly connected to a microammeter calibrated in foot-candles of sunlight is now being regularly produced and has already found considerable demand in the forestry and agricultural fields. A 3-range instrument calibrated, with quartz windows, for sunlight intensities of 100, 1000, 10,000 foot-candles covers most requirements but the calibration can just as well be made to cover any set of ranges up to 20,000 foot-candles.

Since a quartz windowed "photronic" cell is sensitive to ultra-violet radiation in addition to the visible sunlight (Fig. 3) and since the Sunlight meters are actually calibrated with natural sunlight, very favorable results are being obtained.

It is now possible to measure, in a few minutes, the sunlight reaching a field or forest whereas previously hours would be consumed obtaining a similar survey. At times the sunlight varies so rapidly and continuously that it is practically impossible to obtain accurate data with any device which is not direct reading.

Sunlight Recorder

Where it is desired to obtain a permanent continuous record (Fig. 1) of sunlight, north sky light, or any value of natural light, it is a simple matter to mount a cell or cells on a pole or roof (Fig. 2) or other desired location

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*Engineer, Weston Electrical Instrument Corp.

†Described in *Instruments*, Vol. 4, Nov. 1931, page 641. See also "Simple Illuminometer," *Instruments*, Vol. 5, Jan. 1932, page 22; "Direct Reading Illuminometer," *Instruments*, Vol. 5, May 1932, page 136.

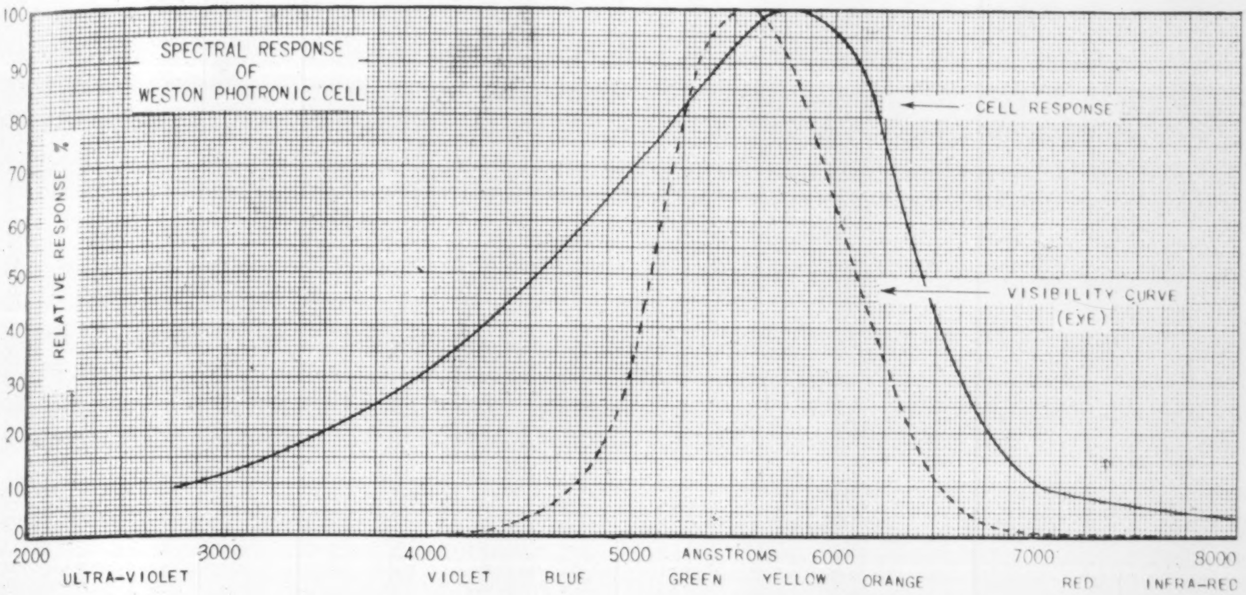

Fig. 3.

and run leads indoors to a recorder. Almost any sensitive recorder is suitable—for instance, the type used in pyrometry or gas analysis work.

The sensitivity required will, of course, depend on the range of illumination to be measured. Since the cell produces approx. 1.4 microamperes per foot-candle and since standard recorders can be obtained to operate on as low as 100 microamperes for full scale, a range as low as 100 foot-candles can readily be obtained with just one "photronic" cell. If lower ranges are required, it is only necessary to connect a sufficient number of cells in parallel.

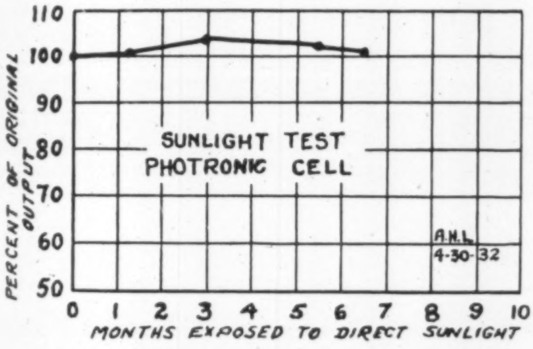

Fig. 4. 6½ Months Exposed to Direct Sunlight Under Full Load (sometimes exceeding 8 MA.) and still "going strong."

More Cells—More Power—More Flexibility

While the "photronic" cell produces approx. 120 microamperes per lumen, a value about twice as great as that produced by the most sensitive photo tubes, there are still some requirements where greater current output is necessary. However, this can be taken care of readily without resorting to such relatively troublesome, expensive and cumbersome devices as one or more stages of amplification.

The solution is as simple as connecting two dry cells in parallel: The current supplied to a meter connection to two or more "photronic" cells in parallel is practically a direct proportion of the number of cells. Two cells are made use of to operate the foot-candle meter and three cells to operate the illumination control relay. In one instance, an indicator having a full scale range of 1 foot-candle (0.02 ft-cand. per div.) was required. This was obtained by connecting sixteen "photronic" cells in parallel—all mounted as a unit which fitted into the cover of the instrument. These cells weigh so little that even such a number of them can be carried more easily than an amplifier.

The "photronic" cell is permanent and will stand up under any current drain and light intensity including full sunlight. Therefore, any metering device with which it is used is free from ageing errors, periodic replacements, etc., and if handled with the care usually shown a voltmeter or ammeter, will last as long as one.

Old Sol Throws Switches

The sun can be made to play the rôle of switchman for turning lights on at dusk and off at dawn and actual tests over a period of months have shown that he accomplishes this with greater regularity and more consideration for actual requirements than any human switchman or clock operated device.

By suitably calibrating the relays in the circuit,* it is possible to have lights turned on and off at 5 foot-candles or any higher value, or to be turned on at 5 and off at 10, etc.

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*See *Instruments*, Vol. 5, July 1932, page 182.

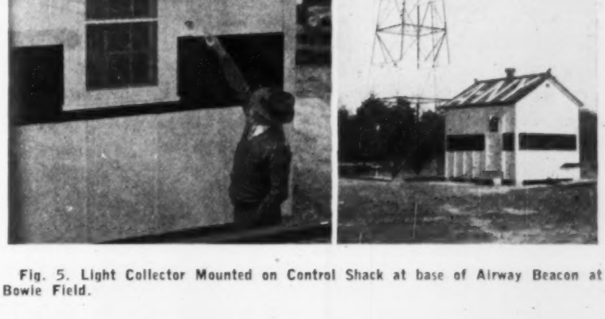

Fig. 5. Light Collector Mounted on Control Shack at base of Airway Beacon at Bowie Field.

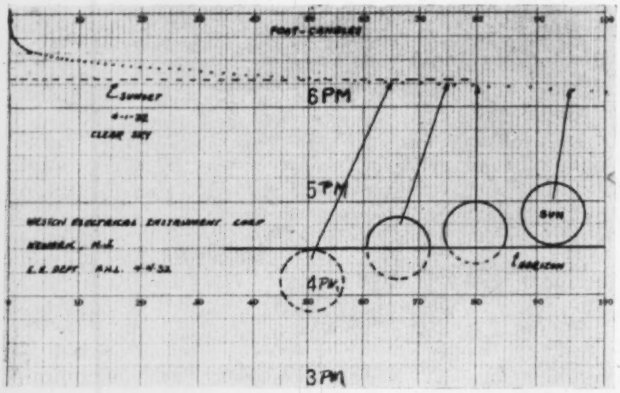

Fig. 6. Recorder Chart Showing Relation Between Light Intensity and Position of Setting Sun.

Outfits similar to those pictured have been under test for some months at the Elm Tree Marine Lighthouse on Staten Island and at the Bowie Airport on the New York-Washington Airway. In various other parts of the country similar installations are controlling street lights, flood lights, large signs, etc.

The Elm Tree Light is arranged to be lighted at 10 foot-candles. This value is reached a few minutes after sunset on a clear day and sometimes a half hour to an hour before sunset on stormy days. During heavy thunder storms and other dark periods the light will be lighted for a short time. At dawn the light is turned off at 20 foot-candles. This higher adjustment is optional and, as in this installation, can be made use of to hold the light on a bit longer in the morning as there is usually considerable ground haze and fog which causes poor visibility not usually encountered at sunset.

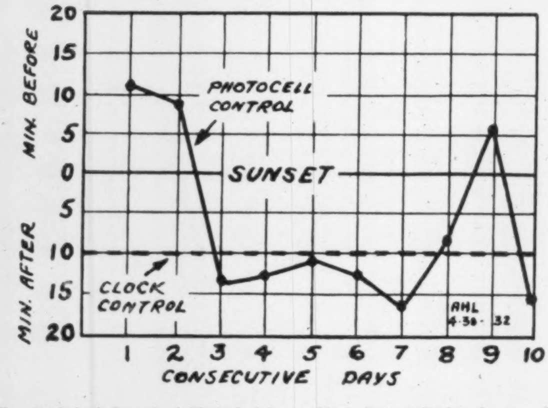

Fig. 8. Actual Record of Photoelectric vs. Clock Control During January, 1932, in Large Eastern City.

The airway installation at Bowie Field, Md., is arranged to start the beacon and field lights in the evening after the natural illumination has dropped below 15 foot-candles. The field then remains lighted until morning and lights are turned off after daylight exceeds 30 foot-candles. The higher foot-candle adjustment for the dawn is again found desirable as, although the sky is well lighted, the ground is usually covered with a haze and the field markings are indistinct as viewed by the aviator.

All of these control devices are purposely arranged to have a time lag of one minute or thereabouts so that false operation would not be caused by a shadow in the daytime or a lightning flash at night.

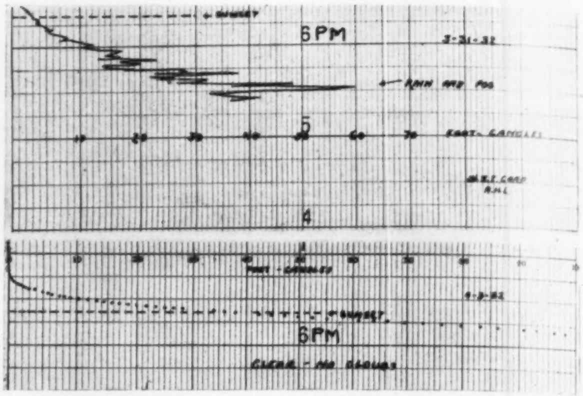

Fig. 7. Recorder Chart Showing Extra Protection would be Afforded Aviators During Storm or Fug with Higher Foot-Candle Adjustment.

"Photronic" Cell Controls Department of Commerce Exhibit

As part of the Washington Bicentennial program, the Airways Division of the Aeronautics Branch of the United States Department of Commerce has arranged a model Airways Exhibit in the Dept. of Commerce building at Washington, D. C. A complete, full-size beacon is arranged so that it is operated each time a visitor stands to read the sign describing the apparatus. A "photronic" cell light collector is buried in the sign and a shadow such as that thrown by a person standing in front of the sign causes the beacon to light and rotate until the person steps away.

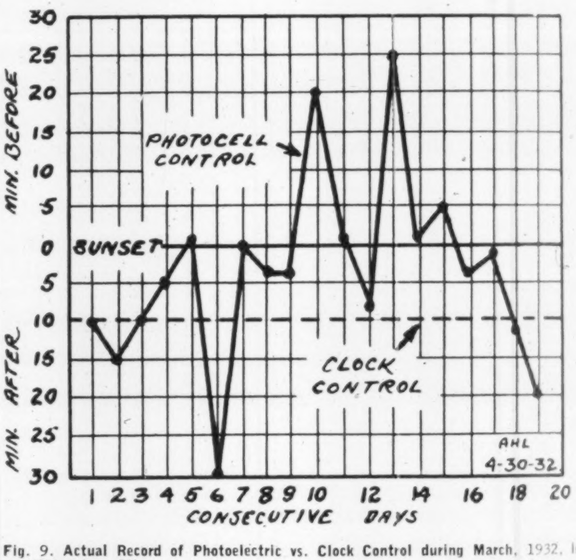

Fig. 9. Actual Record of Photoelectric vs. Clock Control during March, 1932, in Large Midwestern City.

Light Drops Rapidly as Sun Sinks Below Horizon

As the sun sinks below the horizon the illumination decreases rapidly and the span from 50 foot-candles to 5 foot-candles is only a matter of 10 to 15 minutes. It is wise, therefore, to avoid setting the equipment for too low a value—rather it should be set for a value of at least 25 foot-candles for airports and 50 foot-candles on radio towers and other airway obstructions and thus afford full protection at twilight and quicker operation as storms and fogs approach.

Street Lighting Contracts Hinder Photoelectric Control

Municipalities usually have a contract with the local power company specifying that the street lights must be lighted at some definite time after sunset and extin-

(Continued on Page 236)

The ENGINE INDICATOR

By KALMAN J. DeJUHASZ*

Its Design and Theory

(Continued from September Issue)

INDICATORS FOR SPECIAL PURPOSES

Indicators for Ammonia Compressors. This gas has a corrosive effect on copper and brass. Therefore all the indicator parts (valve, cylinder) which come into contact with the ammonia are made of steel or cast iron. Such a cylinder lining is shown on Fig. 16 g. Using a bronze steam engine indicator occasionally on ammonia compressor does not damage the instrument, if it has been carefully oiled.

Indicators for Locomotives (Fig. 61) have to be very sturdily built in order to withstand the violent vibrations to which they are subjected in service. For this reason the union nut connecting the indicator to the valve is made very strong. The indicator cock is actuated from the engineer's cab by a chain and sprocket or other positive drive as is shown in Fig. 6a. Likewise, the recording gear is actuated by electromagnets. The paper drum contains a long strip of paper wound on a supply spool, upon which a large number of diagrams can be taken. The drum is also operated by remote control. The general arrangement on the locomotive is shown in Fig. 61b.

INTEGRATING INDICATORS

If the engine load undergoes rapid fluctuations, then a diagram taken at regular intervals, i.e., in every 2 or 3 minutes, does not represent a true average for that time interval and may lead to quite erroneous conclusions as to steam consumption and economy of the engine. This is the case, especially, in engines driving transporting machinery, steel mills, locomotives, machine tools and the like. In such cases it is necessary to take diagrams in rapid succession and even to record every single engine cycle.

There are drum constructions for such purposes in which a long strip of paper is used for recording every consecutive cycle. (See Figs. 37, 39.) The manual planimetering of a large number of diagrams, however, entails a considerable and even prohibitive amount of time and labor.

There are devices available, the so-called planimetering (or integrating) indicators, or work-meters, which automatically perform the continuous measurement of the work done, combining in one instrument the function of the indicator and of the planimeter.

An example of such apparatus is the work-meter developed by Gümbel, shown in Fig. 62 a and b. Its principle (Fig. 62c) is that a measuring wheel is given a rotation proportional to the product of piston force and piston travel by means of two disks, which can be de-

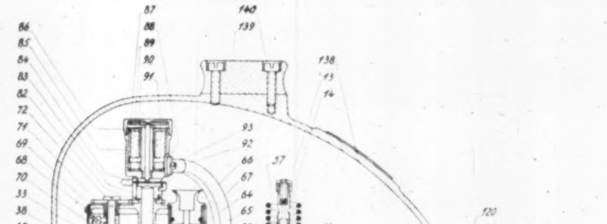
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Fig. 61. Locomotive Indicator (Maihak). The pencil is pressed onto the drum by electromagnet 108 and the drum motion is also set into operation with an electromagnet 85. All the electrical connections are made by the sturdy connector 117-133. Hood 138 protects the apparatus from the weather and from injury.

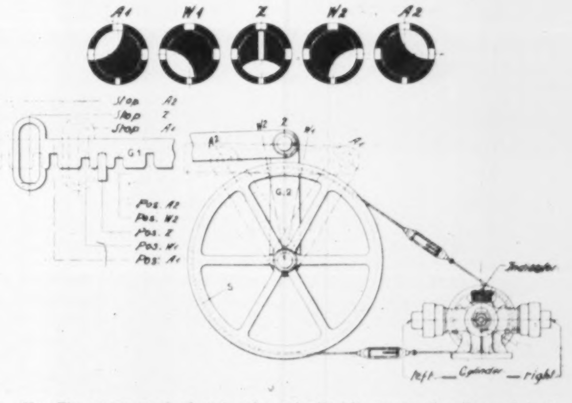

A1
W1
Z
W2
A2
Stop A2
Stop Z
Stop A1
G1
W2
Z
W1
A2
A1
G2
Pos. A2
Pos. W2
Pos. Z
Pos. W1
Pos. A1
S
Indicator
left — Cylinder — right

Fig. 61a. The arrangement of cock valve actuation by means of pulley and lever, and also the five operating positions of the cock:

A1 Indicator connected with Left side of Engine Cylinder
W1 Atmosphere connected with Left side of Engine Cylinder
Z Idle Position
W2 Atmosphere connected with Right Side of Engine Cylinder
A2 Indicator connected with Right Side of Engine Cylinder
The actuating lever G_1 has notches for each position of the cock.

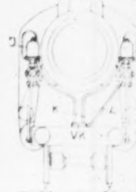
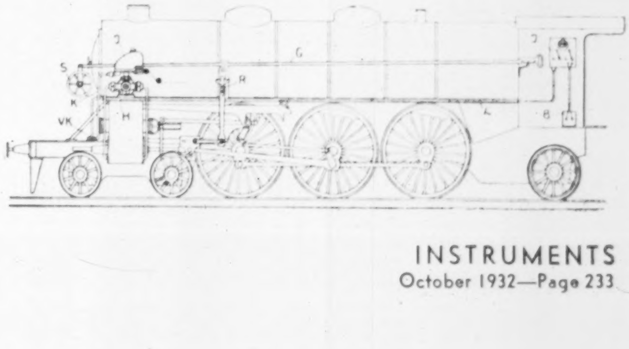


Fig. 61b. The general arrangement of the indicator as fitted to the locomotive. R is the reduction lever actuated from the engine crosshead. Note switchboard for the actuation of the electromagnet.



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*Asst. Professor of Engineering Research, Pennsylvania State College.

Fig. 62a

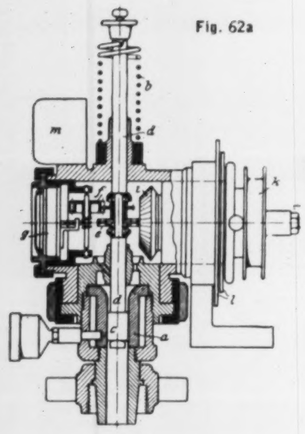

Fig. 62b

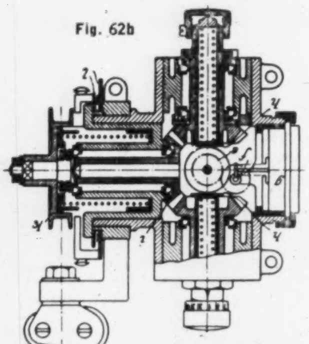

Fig. 62a and 62b. Cross sectional side elevation and plan view of the Guembel work-meter (Lehmann and Michels). Note e force-disk mounted on ball bearings, h travel disks pressed onto e by means of helical springs; k is drive from the engine giving proportional oscillation with the engine piston; g is the counting mechanism connected with a pointer and dial (not shown).

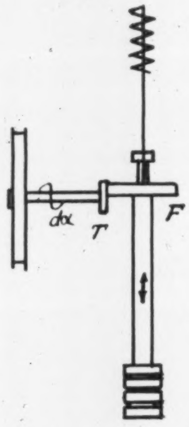

Fig. 62c. Principle of the Guembel work meter.

noted as force-disk (F) and travel-disk (T), in frictional contact with each other. In the construction shown there are two travel-disks pressing against the force-disk from opposite directions. Both are driven from a bevel wheel which latter in turn is driven from the engine in a manner similar to an indicator drum. Therefore, the angular travel of the travel-disk will be proportional to the displacement of the engine piston. Pivoted on the rod of a spring loaded piston, similar to an indicator piston and spring arrangement, there is the force-disk, the axial displacements of which are proportional to the pressure and therefore to the piston force. This arrangement results in a rotation of the force-disk which is proportional to the product of the piston travel and piston force of the engine. The revolutions of the force-disk are counted and summed up by a counter, the reading of which will be proportional to the total work done in the tested side of the cylinder in a given time.

There are instruments which serve for both purposes: taking of individual cards and also for continuous recording of total work done. In these instruments the top of the indicator drum serves the purpose of the "travel-disk" while the "force-disk" is actuated by the piston rod of the indicator by means of a bell crank lever. Such an apparatus is shown in Figs. 63 a and b. This construction, however, involves a large mass for the pressure recording part, and also some inconvenience in handling the paper. Therefore, such a combination cannot perform either function as well as the instruments designed for one single purpose. A recent modification is shown in Figs. 64 a and b, in which a separate "travel disk" is driven off the indicator drum. With this arrangement the taking of diagrams is less inconvenient. In this group of apparatus belongs the power meter developed by A. Frisch[1] shown schematically in Fig. 65. In contradistinction to the integrating indicators which count the work done during a given time this apparatus measures the instantaneous horsepower. The indicated work is proportional to the product of pressure and piston travel while the indicated horsepower is proportional to the product of pressure and piston speed. In the Frisch apparatus this latter quantity is measured

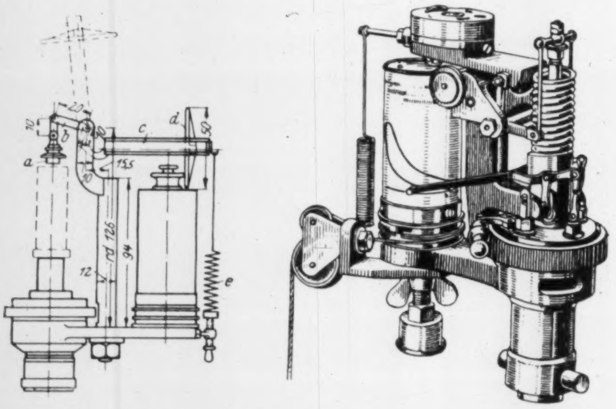

Fig. 63a and b. Boettcher's planimetering indicator shown schematically and in its actual form (Maihak). Force disk d is actuated from the end of the piston rod and is brought into frictional contact with the top of the indicator drum by means of helical spring e. The counting mechanism connected to the force disk is shown in Fig. 63b. The apparatus can be used for taking regular diagrams but it is somewhat cumbersome owing to the necessity of lifting the force disk into the position shown in dotted lines on Fig. 63a, whenever a new card is to be put on.

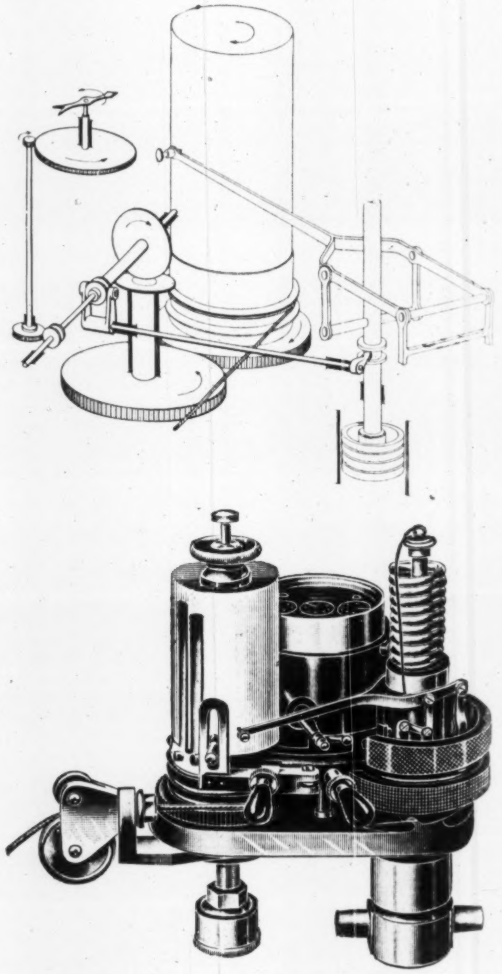

Fig. 64a and b. Scheme and actual form of a recent modification of Boettcher's planimetering indicator (Maihak). In this the difficulty of putting on and removing the card is obviated by the use of a separate "travel disk" driven off the indicator drum by means of tooth wheels. The "force disk" is actuated from the indicator piston rod by means of a collar and levers.

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[1] A. Frisch. Concerning a new method and apparatus for directly measuring the indicated output of reciprocating engines. Fachschriften Verlag, Zuerich, 1919, 22 pages.

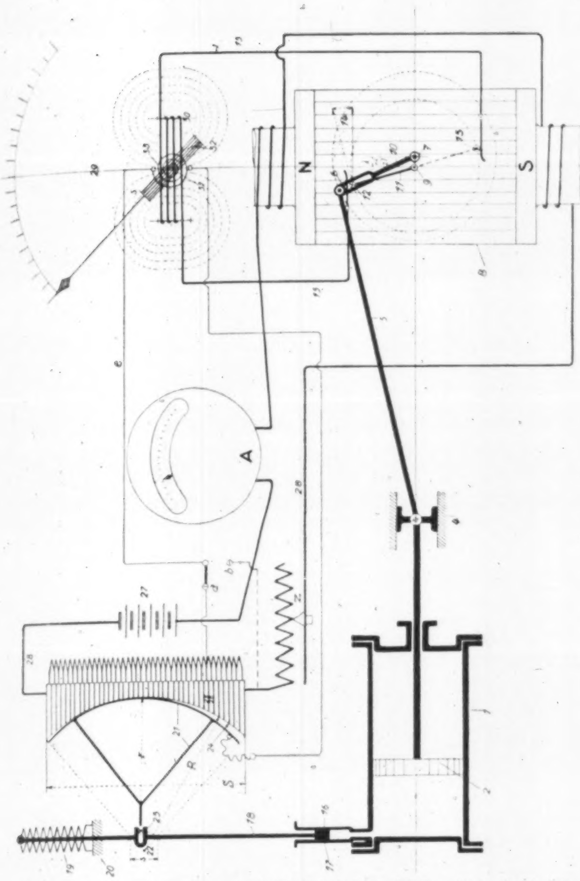

Fig. 65. Schematic arrangement of the Frisch Power Meter. 1, 2, 4, 5, 10, 7, engine cylinder, piston, crosshead, connecting rod, crank, crankshaft. 9, 11, 12 offset crank mechanism of speed transmitter. 12, 13 coil of speed transmitter armature. 8 homogeneous magnetic field excited by battery 27, and conduit 28. 15 wattmeter current conduit. 16, 17, 18, 19, 20 pressure indicator cylinder, piston, piston rod, spring, frame. 21, 22, 23 pressure transmitter roller segment. 25, 26 resistance plates. *e* conduit for movable coil of wattmeter 29.

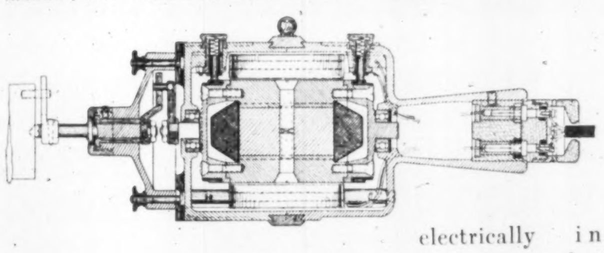

Fig. 65a (above). Speed transmitter unit of the Frisch Power Meter.

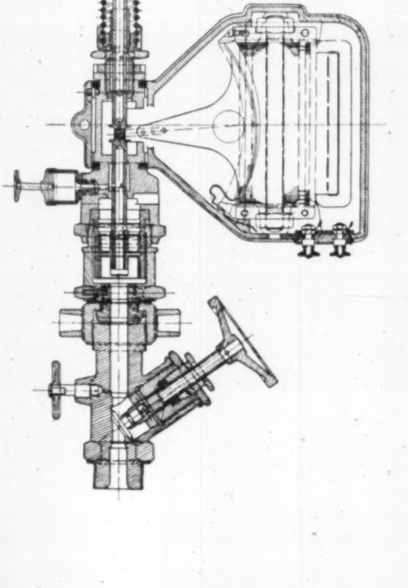

Fig. 65b (at left). Pressure transmitter unit of Frisch Power Meter.

electrically in such a way that the instantaneous piston speed is converted into an electric current, i_s (changing its sign at the change of each stroke) the instantaneous pressure existing in the cylinder at the same instant is converted into a second current i_p (with negative sign for pressures below atmospheric) and the product of the current values is measured with a wattmeter.

The possibility of using this principle depends upon the accuracy with which the piston speed and pressure can be converted into proportional current values and no little ingenuity was expended to attain this object.

The piston speed transmitter (Fig. 65a) is a specially constructed alternating current generator. It is known that in a conductor loop rotating at uniform velocity in a homogeneous magnetic field, an electromotive force will be generated which is a pure harmonic function of the angular position of the loop and is proportional to the angular velocity. Likewise, the piston velocity of an engine having an infinitely long connecting rod is a pure harmonic function of the crank angle. Such a simple generator driven by such an assumed engine would produce, in a circuit having solely-ohmic resistance, a current proportional to the piston speed at each instant. With an engine having a finite crank / connecting rod (r/l) ratio, the piston velocity is not a simple harmonic function. Therefore it is necessary to give the conductor loop a non-uniform angular velocity in order to obtain a current proportional to the piston velocity. This objective is attained by driving the rotor from the engine shaft through an intermediary, eccentrically placed slotted crank mechanism. It can be shown from the kinematics of the crank mechanism that the desired non-uniform rotation is attained if the center of the rotor is offset, with reference to the driving (slotted) crank moving with uniform velocity, by the amount $r^2/2l$ where r is the length of the driven crank and r/l is the crank/connecting rod ratio of the engine. In this case the projections of the driven crank, and hence the lines of force cut by the loop, will be proportional to the instantaneous piston travel, which satisfies the requirement. (The displaced center method, originated by Brix, is a widely used graphical means for determining the piston positions corresponding to a given crank angle for a finite crank/connecting rod ratio and its proof is given in textbooks on kinematics.)

A problem inherent with this method of speed conversion is the difficulty of producing a homogeneous magnetic field. In this device this was solved by making the magnet the rotor inside of the stationary armature. A storage battery supplied the necessary current for the electromagnet. By giving the pole shoes a radius of curvature 0.95 times that of the internal radius of the armature a satisfactory conformity with the sine curve was obtained. Another problem was to insure a proportionality between the r.p.m. and the electromotive force. This was satisfactorily solved by constructing the generator of such a size that the maximum load due to the measuring instrument is 10% less than the maximum output of the generator, whereby the voltage drop in the stationary armature is reduced to a sufficiently low value. A third source of error, caused by the twisting of the field owing to the armature reaction, could be satisfactorily compensated by turning the stator a few degrees backwards when the speed increases.

The pressure transmitter (Fig. 65b) is substantially a spring loaded indicator actuating a variable electrical resistance instead of the usual writing mechanism. The resistance plates form a stationary unit and are shaped as a concave cylindrical segment. Upon this rolls the convex roller segment actuated by the indicator piston rod. This arrangement works as a multiplication. If S_1 (Fig. 65) is the range of the contact path and s_1 the indicator piston's total travel the ratio of transmission will be:

$$m = S_1/s_1$$

If R is the radius of the concave contact segment and r the radius of the roller segment we obtain:

$$r = R - R/m$$

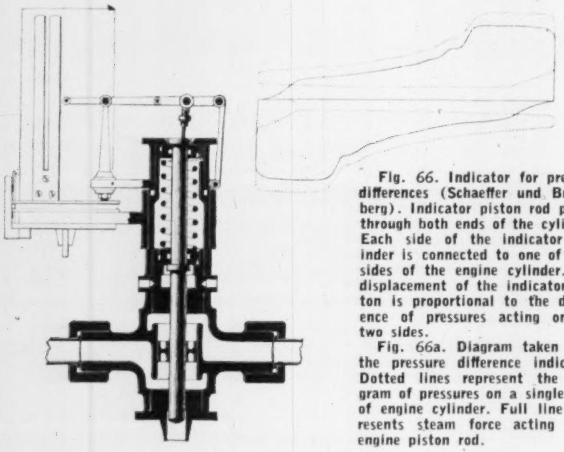

Fig. 66. Indicator for pressure differences (Schaeffer und Budenberg). Indicator piston rod passes through both ends of the cylinder. Each side of the indicator cylinder is connected to one of both sides of the engine cylinder. The displacement of the indicator piston is proportional to the difference of pressures acting on the two sides.

Fig. 66a. Diagram taken with the pressure difference indicator. Dotted lines represent the diagram of pressures on a single side of engine cylinder. Full line represents steam force acting upon engine piston rod.

A large number (say 15 for 10 lbs./in.^{2}) of resistance plates and contacts are used in order to approach as close as possible to a stepless connection and disconnection. The contact plates are insulated with mica whereupon they are internally turned and ground. The roller segment is made of iron and its contact surface is heavily silver plated. Contact between the faces is insured by an electromagnet, the pole plates of which are placed on both sides of the roller, which pulls the contacting surfaces towards each other.

The power measuring device is a wattmeter upon which the 2 currents are impressed, especially constructed to attain a large deflection with small watt losses.

INDICATORS FOR PRESSURE DIFFERENCES

In a broader sense a normal type of indicator records not an absolute pressure (i.e. pressure above vacuum) but the difference between the engine cylinder pressure, acting upon one side of the indicator piston, and the atmospheric pressure acting upon its other side. The usual diagram represents the forces acting upon one side of the engine piston only. Therefore for the determination of the engine piston rod forces two diagrams, one each for both sides of the engine piston, are necessary.

Indicators have been built in such a manner that each side of the indicator piston can be connected separately to one of both sides of the engine cylinder (Fig. 66). In this case the displacement of the indicator piston will represent the difference of pressure acting upon the two sides of the engine piston at given instant, i.e. the net steam force acting upon the piston rod. Such a diagram is shown in Fig. 66a and its area will represent the indicated work done on both sides of the engine piston during one complete engine revolution.

A similar principle is employed when it is desired to record comparatively small pressure fluctuations below and above a high absolute pressure. This is the case in a hydraulic accumulator in which the hydraulic plunger is loaded by a piston upon which acts the pressure of air, contained in a reservoir, shown schematically in Fig. 67. The air pressure changes slightly owing to expansion and compression, whenever the hydraulic plunger is displaced. R. Sackheim has devised a supplementary device for an indicator which makes possible the recording of pressure fluctuations with a high degree of accuracy. The device (Fig. 68) consists of a differential piston upon one side of which acts a constant steady pressure while on the other side acts the fluctuating pressure. In this manner only the differences above and below the steady pressure are registered and these appear on a large scale. The axial friction is eliminated by rotating the differential piston, in a manner shown on the drawing. It is stated that this device is able to record a fluctuation 1.5 lbs./in.^{2} above or below a basic pressure of 7000 lbs./in.^{2}

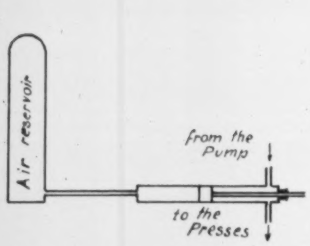

Fig. 67. Arrangement of hydraulic accumulator combined with pressure air reservoir.

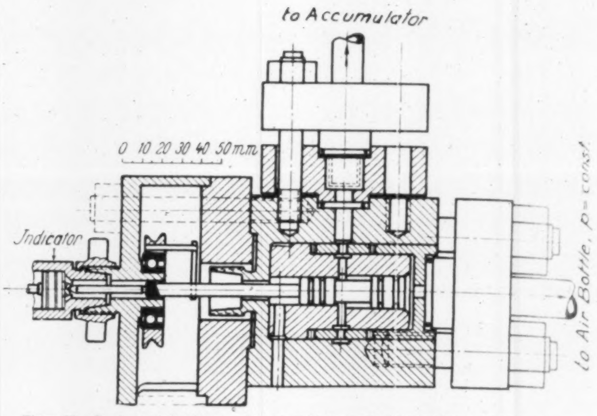

Fig. 68. Device of Sackheim for recording small fluctuations of high pressures. Accumulator pressure acts upon annular area of differential piston. Constant pressure of an air bottle acts upon larger circular area of piston. Difference of forces is transmitted to piston rod of indicator. (The indicator piston proper is exposed on both sides to the atmosphere, hence its role is solely to guide the piston rod.) Pulley device serves to rotate the differential piston in order to eliminate axial friction.

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Free Electricity While the Sun Shines

(Continued from Page 232)

guished before sunrise. This time varies anywhere from a few minutes to three quarters of an hour. On many days, our records show, some street lights are lighted while the sun still shines and the same street lights are

(Continued on Page A7)

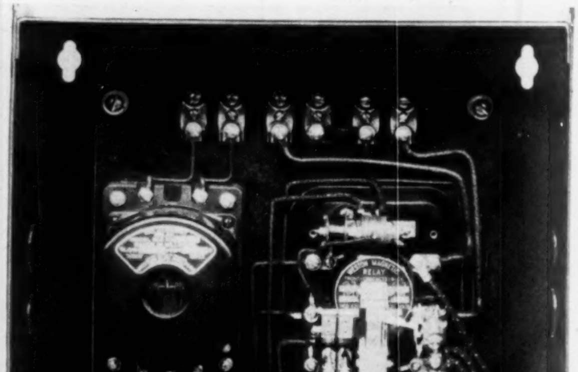

Fig. 10. "Photronic" Illumination Control Relay.

Flow Measurement and Control*

By M. F. BEHAR†

CHAPTER XXIV
CURRENT METERS

3. General Characteristics
(b) Open-Stream Types

(Continued)

In the *Engineering News Record* of Nov. 18, 1926, there appeared a review of *Der Genauigkeitsgrad von Fluegelmessungen bei Wasserkraftanlagen* by Prof. Dr.-Ing. A. Staus. Extracts:

> Fully half of the pamphlet is devoted to a discussion of the current meter of the propeller type—more specifically the latest models of the Ott current meter.
>
> The Price current meter, the official meter of the U. S. Geological Survey, is attacked and given no quarters . . . is pronounced faulty in principle of construction, unreliable and obsolete—in short, it should be relegated to a museum of curiosities.

Interesting letters, provoked by these statements, appeared in subsequent issues. Extracts:

By K. K. Hoyt, General Engineer, Water Resources Branch, U. S. Geological Survey:

. . . Dr. Staus favors the Ott meter, a direct or propeller type. The U. S. Geological Survey abandoned the direct type some years ago, except for measuring discharge in small pipes, because its practical disadvantages outweighed its theoretical superiority. Direct meters have mechanical weaknesses; do not stand up under hard usage; are subject to change in rating if struck by floating ice or débris; easily clog with weeds; do not accurately register low velocities. Attempts have been and are being made to remedy these faults. In the meantime the rugged, reliable Price functions admirably under conditions good and bad alike. The Au (improved Price) meter has the additional advantage of giving very low velocities with accuracy hitherto unknown.

By Benjamin F. Groat, Consulting Engineer, Philadelphia:

. . . The usual still-water rating cannot be relied upon when the meter is subjected to conditions of turbulent flow. If extreme accuracy is required, as in turbine testing, then it is necessary to employ more than one type of meter, unless most unusual conditions of quiet flow exist, as in long, straight uniform canals.

In selecting two different kinds of meters for simultaneous use in a gaging section, a meter of the cup type . . . and a meter of the propeller type . . . should be chosen—for meters of the former type over-register in turbulent water while those of the propeller type, unless of very unusual design, *under*-register. The discrepancy between the two velocities given by the two meters is then a criterion of the degree of the error, and is generally greater than the error of either meter.

Moreover, a composite reading may be made from which a plane composite isogram can be plotted showing the true velocity as a function of the two velocity observations at the same point in the gaging section, the velocity by one meter being one co-ordinate, the velocity by the other meter being the other co-ordinate, and the true velocity being read from the isographic graphs.

. . . There seems to be no reason for criticism of the performance of any type of meter. Different types of meter are simply different types of measuring instrument. Each type must be calibrated. If there is any error in results it is due to error of engineers in applying the instruments. Because one engineer prefers to use a particular make of instrument is no reason why he should criticize the practice of other engineers who prefer to use a different make. A good engineer simply adapts his practice to the type he employs. "Accepted practice" in the general sense is often a dangerous practice, because it is so apt to become perfunctory practice. . . .

The statement that screw meters ensnare weeds and the like is misleading to the extent that it does not apply to a properly designed runner, in fact such a design (Haskell) is as safe in this respect as any cup meter.

4. Characteristics in Turbulent Flow

With most other classes of fluid meters, turbulent flow makes no difference in the readings or produces similar positive or negative effects on the readings of various models of meters of one type. It is not so with current meters. Even if it were possible to set up a test conduit in which all individual vortices, velocity fluctuations, etc., were reproducible, it would not be proper to com-

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*Part Six of *The Manual of Instrumentation.*

†Engineering Editor.

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pare the readings of two current meters placed alternately at one point. The principal reason is that different current meters intercept different areas or different shapes of stream section, so that the local turbulence to which one is exposed is not the same as that affecting another. Much exact information is available on the statistical or macroscopic character of various kinds and degrees of turbulent flow, but local turbulences are never predictable for, as F. L. Richardson has summed up:

> Big whirls have little whirls that feed on their velocity
> And little whirls have lesser whirls and so on to viscosity.

Even in the case of comparing two meters of the same make and model, it is advisable to test them at a number of different points in a measuring section when flow is non-parallel, because each meter alters the local turbulences and no two meters modify them alike. Therefore no two meters are subjected to the same resultant turbulences.

Yarnell and Nagler in the aforementioned paper report a number of experiments on cup type and screw type current meters located at a number of points of a section where turbulent flow was artificially produced. Their report is the richest source of information on this subject at the present time. Following are extracts from it and from the discussion papers.

> . . . In the canai, below a water-tight bulkhead, was constructed a smooth concrete box-flume, 4 ft. wide, 4 ft. deep, and 36 ft. long, in which all the experiments were made. The meters were held by rigid rod suspension in the water, 10 ft. up stream from the lower end of the flume.
>
> . . . The smooth rounded entrance of the flume produced a stream of remarkably uniform velocity, much like a jet flowing from an orifice. When there was no obstruction in the flume, measurements with a current meter at eight different points in the cross-section showed almost no measurable variation in velocity.
>
> . . . Since the study was concerned with the change in the reading of the meter for a certain definite change of conditions . . . it was decided . . . to compare each meter with itself only; that is, in each test the meter reading under [standard] conditions was compared with the reading of the same meter when some abnormality of condition had been introduced.
>
> In the first or preliminary series of experiments, in the flume carrying a constant quantity of water, varying degrees of turbulence were purposely created by the insertion of different types of baffles and obstructions. These obstructions were designed to create

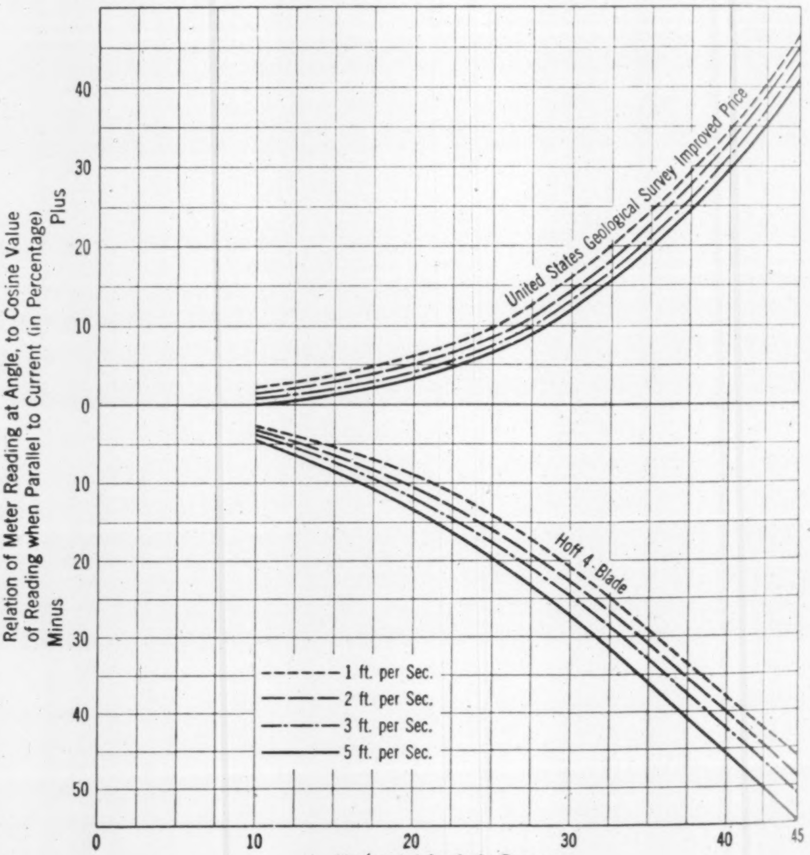

Fig. 24-2. Diagram Showing Effect of Holding Two Types of Meters at Various Horizontal Angles with the Direction of the Current. (*Yarnell and Nagler*)

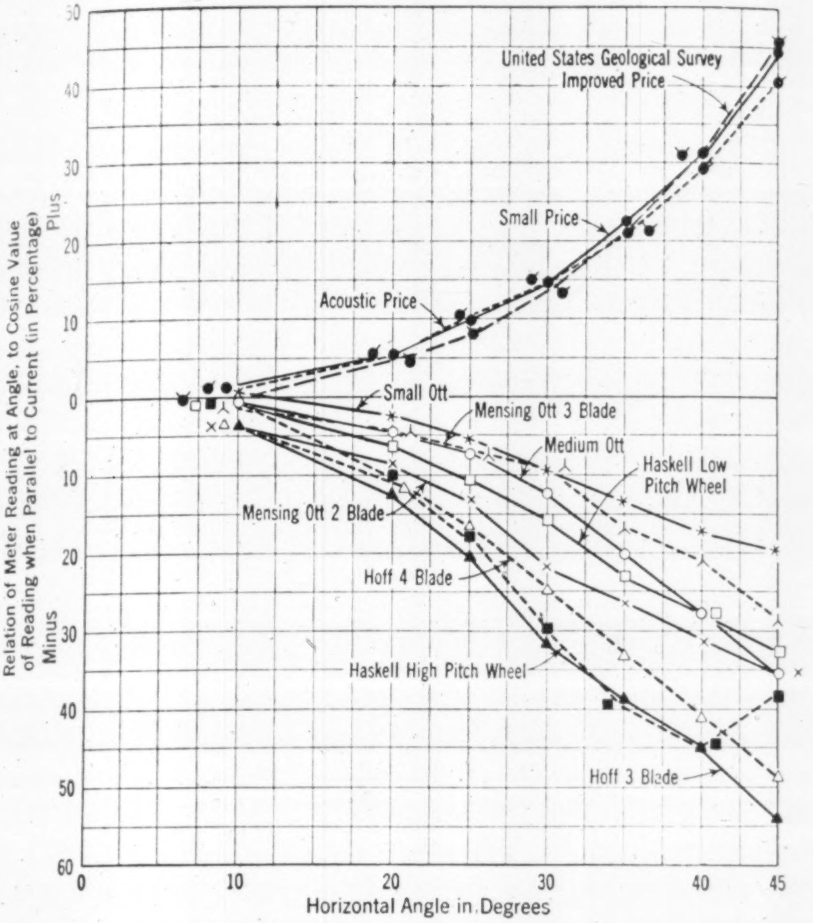

Fig. 24-3. Maximum "Errors" of Eleven Different Current Meters Held at Various Horizontal Angles With the Current (*Yarnell and Nagler*).

a definite and fixed constant disturbance in the flowing stream of water. Each meter was then held in turn at eight fixed points in the flume downstream from the obstruction.

The fixed obstructions creating the turbulence were placed in the flume 6 ft. upstream from the testing section. In some experiments the eddies were produced by either vertical or lateral obstructions in the flume made by a submerged triangular dam, or by a vertical pier, but the most disturbed condition was obtained by devices resembling stationary paddle-wheels. The disturbances set up by the stationary paddle with a vertical axis were quite different from those produced by that with the horizontal axis. The horizontal axis was placed so as to hold the lower edges of the paddles 3 in. above the floor.

. . . The apparatus designed to create rapid changes in the relative velocity of the water with respect to the meter [comprised a] large wheel . . . rotated at any desired speed, so as to cause the cross-head holding the meter rod to move back and forth through a stroke of 2 ft. in a definite manner approaching a simple harmonic motion. The connecting rod, however, was only 2 ft. long; hence, the motion of the piston was asymmetrical and the piston attained a maximum velocity somewhat greater than that of the crankpin. Although the operator attempted to rotate the wheel at a uniform speed, probably the downstream stroke was completed in a slightly shorter period than the upstream stroke, since greater resistance was encountered in moving the meter against the current, and there was very little fly-wheel effect in the mechanism.

All the meters . . . except [the Price acoustic] were attached in turn to the apparatus and tested in four different quantities of flow, giving average velocities in the channel of 1, 2, 3, and 5 ft. per sec. Under each of these flow conditions, the meters were held 1 ft. below the surface of the water in the center of the channel, and the mechanism was rotated at speeds of 5, 10, 15, 20, 25, 30, 40, and 50 rev. per min. . . .

[*Effect of Stream Filaments Striking the Rotating Element at Various Angles*] When a current strikes the wheel of a meter in a diagonal direction the ideal meter . . . should register only the component parallel to the axis of the meter and normal to the gaging section. This component is equal to the actual velocity of the water multiplied by the cosine of the angle between the meter axis and the stream line of the current.

. . . When tested in the four different velocities of flow, the same meter generally showed a slight variation in performance for the same angles. The extent of the difference is indicated in Fig. 24-2 for one of the cup and one of the screw meters. While the variation is not large, repeated checks demonstrated that the difference observed was not accidental, but that there was a significant variation in the performance of the meters under the influence of currents of different velocities.

A weighted average of the results secured from each meter when using velocities of 2, 3, and 5 ft. per sec., was computed by giving each separate result of weight proportional to the velocity under which it was obtained, and taking the water approaching the meter from either side gave the greater divergence from the ideal. The maximum erroneous effect of oblique currents thus revealed is plotted in Fig. 24-3.

MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

309 Grain Testing Instruments. 48-page catalogue No. 291 of Louis Schopper, Leipzig. Testing Machines, Inc., New York.

310 The Graphic. No. 4321 is devoted to power industry news items. The Esterline-Angus Co., Indianapolis, Ind.

311 Photocell and Relay. 6-page folder on LuxTron Cell and LuxTron "R-1" Relay describes these, with application diagrams. LuxTron Mfg. Co., New York.

312 Gun Detector. Magnetic device at door sounds alarm when firearm bearer enters. Central Engineering Labs., Chicago, Ill.

313 Starters. 4-page Bulletin 110 describes across-the-line type a. c. starters. Square D Co., Milwaukee, Wis.

314 Contactors. 4-page Bulletin 111 describes d.c. and a.c. reversing magnetic contactors. Square D Co., Milwaukee, Wis.

315 Gas Service Journal. The July number's leading article is "The Orifice Meter as Used in the Gas Industry" by A. D. MacLean; editorial on "Lobbying" urges press to drop attacks on utilities. Pittsburgh Equitable Meter Co., Pittsburgh, Pa.

316 Foot-candle Meter. Circular M-1 is titled "Measured Lighting, a New Source of Economy." Weston Elec. Instrument Corp., Newark, N. J.

317 Photoelectric Relay. Bulletin 156 describes and lists applications of G-M Foto-Switch. G-M Laboratories Inc., Chicago.

318 General Radio Experimenter. June number's leading article is on Wave-form Studies with the Cathode-ray Oscillograph. General Radio Co., Cambridge, Mass.

319 Temperature and Pressure Controllers. 4-page Bulletin 1042 describes "Snapon" Types "R-7" and "CS-5" in temperature and pressure models. C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

320 Thermometers. 4-page Bulletin 1040 announces miniature size recorder and square-case dial indicator. C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

321 Humitrol. 4-page bulletin on hygroscopic instrument for controlling equipment which may either add or withdraw moisture from the air. Lewis Air Conditioners, Inc., Minneapolis, Minn.

322 Radio Test Equipment. Salesmen's catalogue insert sheets with data on radio tube and set testing equipment. The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.

323 Portable Hardness Testing Instruments. Bulletin H-2 discusses the use of the Duroskop in the hardening of steel and the selection of stock to give a desired hardness after hardening; Bulletin H-3 covers conversion curves for converting Duroskop readings to hardness numbers of the Brinell, Rockwell and Scleroscope systems; Bulletin H-4 is on the Duroskop, Dwarf Brinell Press and Triplex set of portable hardness testing instruments; H-5 tells of a special form of the Duroskop designed for the testing of wire, drill rod, needles, and other small cylindrical material; H-6 describes a Dwarf Brinell Press adapted to the test of soft metals, using a 250-kg. load with a 5 mm. ball; H-7 covers a special Laboratory Duroskop with variable height of fall of the pendulum, adjusted by means of an angle scale, useful in testing hardness of varnish and paint films, soft metals or finished surfaces; H-8 discusses Triplex Set for testing cast iron surfaces; H-9 treats of the use of the Duroskop for testing hardness and resiliency of plastic products, rubber, linoleum fiber board, etc.; H-10 tells of the Duroskop for testing all kinds of ceramic products, enameled surfaces, and glass; H-11 gives results obtained with Duroskop for testing hardness of wood; H-12 discusses use of Duroskop in checking hardness of rolls while in manufacture, to discover soft spots before carrying the machining needlessly far; H-13 covers use of Duroskop for measuring hardness of stone, gravel and concrete; H-14 describes tests made with the Duroskop on various samples of thin sheet metal—copper, zinc, steel, etc. R. Y. Ferner Co., Investment Bldg., Washington, D. C.

324 Automatic Reset Timing Devices. Bulletin No. 540 describes automatic reset timing relay, designed to replace dash pot, thermal, and other types of devices. Zenith Electric Co., Inc., 537 So. Dearborn Street, Chicago, Ill.

325 Magnetic Equipment. Bulletin No. 720 describes magnetic switch used on control panels and switch boards, such as are used in theatres, churches, stores, etc. Zenith Electric Company, Inc., 537 So. Dearborn Street, Chicago, Ill.

326 Automatic Temperature Control. Bulletin 177, an attractive 48-page catalogue. A convenient index on the cover makes it simple to locate any particular section. The Foxboro Company, Foxboro, Mass.

327 Precision Borers. The latest model of the Swiss High Speed Precision Borer, No. MP-3C, is described in a new catalogue No. 534 A. The R. Y. Ferner Co., Investment Bldg., Washington, D. C.

328 Minerallac Statiscope. The pocket, overhead and station types statiscope devised for the protection of the electrical worker are described in Bulletin No. 155. Minerallac Electric Company, 25 North Peoria Street, Chicago, Ill.

329 Thermo-Regulator. Bulletin No. 405 announcing the Red Top Thermo-Regulator for maintaining temperatures within one tenth of one degree. Hiergesell Brothers, 2508 North Broad St., Philadelphia, Pa.

330 Measuring Instruments. Bulletin No. 32 describes the LeMag line of engine indicators and other technical measuring instruments. Baldwin-Southwark Corporation, Paschall Station, Philadelphia, Pa.

331 Automatic Industrial Scales. A new bulletin describing a completely redesigned line of automatic industrial scales, including dial track scales, portable pan, portable platform, dormant platform, bench, hopper, etc. The Kron Co., Bridgeport, Conn.

332 Indicating, Recording and Controlling Thermometers. 80-page Catalog 1204 prepared as a summary of vapor tension type instruments, and also a handbook of reference for those engaged in specifying such instruments. The Bristol Company, Waterbury, Conn.

333 Polarization Meter. List L 12 describes instruments for measuring the luster of white paper, the blackness of paper, etc. Akatos, Inc., 114 Liberty St., New York.

334 The General Radio Experimenter. August number features the article, Telephone Transmission Measurements. General Radio Company, 30 State Street, Cambridge A, Mass.

334 Tensometers. 12-page Bulletin 37, on the line of lever type strain gages known as Huggenberger Tensometers, discusses the fundamental principles of these instruments as well as applications. Baldwin Southwark Corporation, Paschall Station, Philadelphia, Pa.

**INSTRUMENTS, 3619 Forbes St.,
Pittsburgh, Pa.**

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

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Name..

Position..

Firm..

Street and No..

City.................... State....................

Conclusions and Limitations

The following general conclusions seem to be justified:

1. A flowing stream may be so turbulent as to change very noticeably the readings obtained by a current meter.

2. The disturbances in the current-meter readings are not caused to any noticeable degree by the fact that the flow is unsteady; that is, they are not influenced by the inertia of the current-meter wheel, nor are they produced necessarily when there are pulsations or any unsteadiness in the stream.

3. The variations in current-meter readings seem to be due mainly to the obliquity of flow in the filaments striking the meter wheel.

4. When meters are held on a rod in a rigid position, with the meter axis parallel to the general axis of the stream, turbulent flow invariably causes the cup meter to over-register and the screw type to under-register.

5. The cup meter registers the true velocity of currents approaching the meter from almost every horizontal direction; hence it over-registers the component perpendicular to the gaging section of horizontally oblique flow. Obliquity of flow in a vertical direction has a slight tendency to cause under-registration and thus may compensate to some degree for the over-registration caused by horizontal obliquity.

Certain limitations should be mentioned. This study was not an attempt to make a careful or sweeping comparison of meters produced by different manufacturers, and the figures shown should not be used for this purpose.

It should be remembered also that rod support was used in all these experiments, and the conclusions must not be applied without modification to cable-suspended meters. In a majority of cases, stream gaging is done with cable-suspended meters. In such suspension the tail-vanes tend to keep the meter squarely facing the current regardless of any local or temporary obliquity of flow. In some places, however, such as close to the sharp corners of piers or obstructions, the curvature of the filaments may be so sharp that the direction of flow at the meter wheel is appreciably different from that at the vane. In such case oblique flow must necessarily strike the current wheel. Furthermore, the dynamic center of some meters does not coincide with the mechanical center. Since the suspension by cable comes in a line with the mechanical center, there may be sufficient eccentricity to cause the meter to swirl unduly in the water.

Finally, it is to be remembered that the question of accuracy of registration, discussed in this paper, is only one of numerous important practical questions arising in the construction and use of current meters. Other questions of importance are cost, convenience, portability, durability, consistency, uniformity, reliability, etc.

EXTRACTS FROM DISCUSSION PAPERS

By N. C. Grover, Chief Hydraulic Engineer, U. S. Geological Survey:

. . . There is a belief apparently widely prevalent, especially among engineers of limited field experience and laboratory workers who are likely to overlook the important aspects affecting field serviceability of the meter, that the propeller (horizontal axis) type of meter is superior in every way to the cup (vertical axis) type of meter. Whatever the theoretical advantages of the former, however, the latter seems to have certain practical aspects of superiority that have been controlling. These are related to delicacy of action, essential accuracy, adaptability to use under a variety of conditions, sturdiness, lightness, and reliability.

. . . The small Price meter is now better adapted to general use than any other meter that has been developed. It is light and yet strong; sensitive and yet durable; it will measure, without great error, velocities ranging from less than $\frac{1}{4}$ ft. per sec.* to velocities sixty times as great. It can be used readily whether suspended by a cable or supported on a rod. It will hold its rating under rough usage; it is easily repaired, is quickly taken apart for cleaning and oiling, and is re-assembled just as quickly without change in rating. It is sensitive, although it is not equipped with ballbearings. It can be used by an engineer working without an assistant. No other current meter known to engineers of the U. S. Geological Survey satisfies these conditions. . . .

. . . Many attempts have been made to develop a propeller type of meter for general use, and engineers look forward with hope to such a meter in the future. . . . There are, however, many difficulties to overcome before the equal of the small Price meter can be produced. The practically frictionless pivot bearing of the vertical-axis type of meter can not be used with the propeller type; cylindrical bearings must be substituted if the advantages to be obtained from the overhung propeller are to be realized. Ball bearings are immediately suggested, but it is still an open question whether such bearings can be made as nearly frictionless as pivot bearings of the vertical-axis type. This will be apparent especially when it is recognized: (1) That the meters must be used in silt-laden rivers at depths greater than 50 ft.; (2) that exclusion of water from the bearings under these conditions is probably impossible; (3) that silt, often gritty, will be forced into them to interfere with the action of, and to increase the friction in, the bearings; and (4) that such bearings are not easily cleaned. In addition, the propeller must be overhung if there is to be no obstruction in front of it. This, of course, entails the use of a shaft of considerable strength and size, thereby increasing the friction and decreasing the sensitiveness of operation of the meter. The wheel must also be perfectly balanced and must remain so under ordinary usage, or it will not operate evenly in water that moves at small velocity, but will tend to stop when the heavy part of the propeller is below the axis. By contrast, a meter of the cup type, equally eccentric on its axis, would continue to revolve in water moving at the same velocity. Even a minor injury to the vanes of a propeller type of meter will change the rating, whereas experience has shown that injured cups of the small Price meter can be pressed into approximate shape in the field and the use of the meter continued without change of rating.

By C. Linden, Scientific Instrument Co.:

. . . Investigations are doomed to failure when it is assumed that the forces which actuate the meter represent only the true velocity. Under ideal conditions this may be very nearly true, but in turbulent waters the flow represents a combination of forces of which the velocity may be only a small part. Judging from the design of some well-known meters it must have been assumed that anything which may be rotated by the forces of flowing water may be rated and thus may become a current meter. If streams proceeded as parallel filaments, this assumption would be true, but such is not the case, and meter rotation is not a definite product to which correcting factors may be successfully applied. Meter rotation is the result of forces of irregular origin. . . .

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*See rating curves below. M.F.B.

. . . Theoretically, stream velocities can be measured as a function of the velocity force, but it is too much to assume that true stream velocities can be secured by mechanical means. . . .

. . . An efficient meter must be sensitive; but sensitiveness may be of two kinds—minimum friction and responsiveness to changes in flow direction. In some vertical-axis meters the friction is almost negligible, and yet they are not affected by changes in direction of flow. Such meters appear more conservative when exposed to turbulent flows than actual conditions justify. . . .

. . . A meter for general purposes, or one which will be required to operate under varying stream or channel conditions, should be of a design having the least flow obstruction; it should have a rotor that will engage the maximum of stream filaments consistent with its size; it should be immune from vertical forces so that it may be used in vertical integration; and, it should have some means of securing a stable position automatically. . . .

By Forrest Nagler, W. O. Smith Corp.:*

. . . It seems, however, that a *polar diagram* is slightly more appropriate . . . for showing the meter characteristics.

. . . A line of investigation carried out by the writer that parallels with surprising closeness [the portion of the Yarnell & Nagler report on inclined-axis readings].

. . . Fig. 24-5 is plotted directly from Fig. 24-4 the radii vectors of the various curves being plotted as percentages of the corresponding radii vectors of the zero circle for angles up to 45 degrees. These curves are plotted according to the small percentage scale at the left of Fig. 24.5. On this diagram the areas, A and B, and, consequently, their respective volumes of revolution about the vertical axis, correspond to the similar areas and volumes for Fig. 24-4. Furthermore, the area of the surface described previously is now determined as the area of a circle of radius (20) in Fig. 24-5. . . .

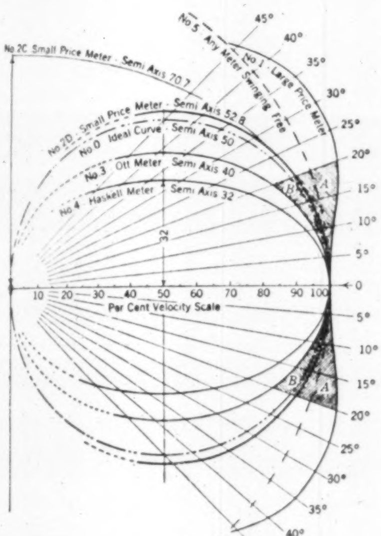

Fig. 24-4. Summary of Contrasting Meter Characteristics.

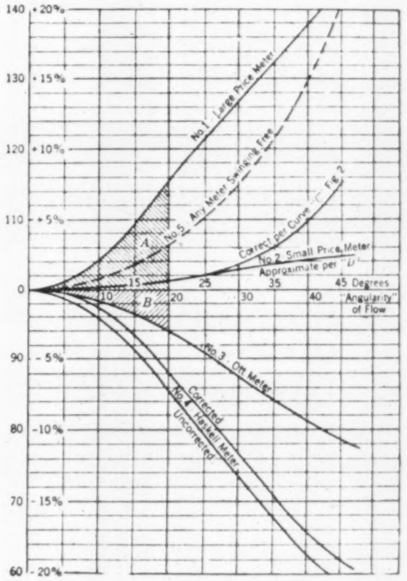

Fig. 24-5. Alternate Recommendation for Plotting Fig. 24-4.

. . . . Fig. 24-5 is represented as a means of reconciling discrepancies found in using meters of all different kinds. The discrepancy between meters of known characteristics is an indication of the degree of turbulence or angularity encountered. What is of greater importance, it might also offer a clue to the correct flow even if that flow is different from the flow indicated by either of the meters. In such application it is desirable to have the two meters under comparison, of diverse characteristics, so that correct flow will lie between them. This is merely because it takes quite a stretch of the imagination to use two such meters as the Ott and the Haskell (which, at an indicated angularity of 30 in Fig. 24-5, may under-register, respectively, 6% and 11½%), and increases the discharges of both of them by the amount in question merely because they happen to differ by about 5½ per cent. Such a procedure, however, is in line with a logical analysis of the data provided in the paper and in this discussion.

By R. E. Horton, Cons. Hydr. Engr.:

An interesting fact brought out by the preceding analysis is that the over-registration of a cup meter in varying velocity can be determined analytically and expressed rationally in terms of the excess kinetic energy of varying flow. The data indicate that [the proportionality factor] f is a constant for a given meter and also that it is an important characteristic of the type of meter. It is apparent that the value of this constant can readily be determined for a given type of meter by the use of apparatus similar to that described by the authors. Some such standard apparatus should be developed and de-

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*Not to be confused with the co-author of the paper on Turbulence who is Floyd Nagler, Prof. Hydr. Eng., Univ. of Iowa.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

First Principles of Television. A. Dinsdale. John Wiley & Sons, Inc., New York, 1932. Cloth, 5 x 8¾ inches, 237 pages. Price $3.50.

The complexity of the problems inherent in television, the multiplicity of refinements made in existing systems, and the rapid progress recently made in the art have tended to confuse the person who is approaching the subject for the first time. This book is up-to-date, and embodies a careful selection of the foremost advances made by the past and present experimenters—weeding out the works of those who have merely duplicated the results of others. It therefore affords the reader a clear perspective of the television art, as developed all over the world, up to the present time.

Starting with a discussion of the principles of optics, photoelectric cells, etc., the author describes the various systems developed, both past and present. Each system is explained clearly, with ample diagrams and illustrations. The author does well not to become too technical, and to clear up those points which often cause confusion. For example, he gives a lucid explanation of the difference between the dot and the modulation theory of television signal transmission, pointing out the erroneous conceptions widely held regarding the former. It is commendable of the author that he is not timid, like other writers in this field, since he does not hesitate to pass judgment on the various systems, and to point out the defects in them.

As one reads this book he becomes more and more impressed with the vast amount of work done on the mechanical systems of television—by Baird in England, in America by Jenkins, and especially by the Bell System. We say "especially" because, as the author ironically points out, the Bell experiments required exceedingly elaborate as well as costly apparatus, and the services of 1000 men. "However, it is characteristic of our friends across the Atlantic (the author is English) that they frequently have to resort to exaggeration in order to impress their fellow countrymen."

It is interesting to note, however, that development activity is shifting away from the mechanical, and is being concentrated more and more on the cathode ray tube systems of television. This fact, though not directly stated by the author, is manifest from his treatment of development trends in Germany and the United States.

A fault of this book, even though a minor one, is very annoying; in no less than 30 places the author refers the reader to "a later chapter," without stating a definite reference. But apart from this, he has presented the subject in a manner which not only grips the reader's interest, but also conveys to him lucidly the background of basic facts in the science of television.

On the whole, the author has, in this book, contributed an excellent, up-to-date treatise on television. We hope he will continue to write on the subject.

—N. Nazar (5.3) **B**

The Photographic Camera. (Handbuch der Wissenschaftlichen und Angewendeten Photographie, Band I. Die Camera.) Edited by M. von Rohr. Julius Springer, Vienna, 1931. Paper, 7 x 10 in. 399 pages. Price RM 46.8.

The comprehensive treatment of the photographic camera in the second volume of this work (see *Instruments*, Feb. 1932, page 50) has now been followed and supplemented by volume I with the equally exhaustive treatment of the optical system of a camera. A most illuminating description of the historical development from the lens-less camera to the modern appliance of many types begins the book, followed by a chapter on the fundamentals of geometrical optics. This chapter and the following on the ideal picture contain the principles of photographic reproduction in clear, simple presentation to which the figures contribute considerably. The different types of lenses and systems of lenses are treated according to the purpose they have to serve, universal objectives, portrait lenses, cinematographic lenses, wide-angle objectives, telephoto objectives, etc. Much space is devoted to the calculation of the lenses and lens combinations; particular attention is paid to their optical properties; numerous examples are given, and for each lens system treated the optical behavior is represented in curves and diagrams. The purpose of additional lenses, light filters and other optical accessories to a lens system to obtain certain ends are discussed in another chapter, and the closing chapter is devoted to the testing of photographic objectives, determination of errors, focal length, effective opening, where the different testing methods are explained and illustrated. In all, this volume has the same good qualities of representation of the subject as the volumes already published.—Max Hartenheim. **(7.6)B**

Mining Electrical Engineering. By H. Cotton, Chapman & Hall, Ltd., London, 1931. Cloth, 8 x 5 inches, 315 pages. Price 15s. 9d.

To educate in electrical engineering—that is in the design of electrical machinery, there are many books, even some good ones. But there are now a great body of men, the industrial plant electricians, who seek instruction not in the design but in the installation of electrical machinery, in its operation, and servicing. For them there are hardly any books at all, and good ones are particularly rare. To find, therefore, in "Mining Electrical Engineering" a book that is as good as the need for it is great, is indeed a welcome occurrence.

This book was intended as a manual of instruction to prepare electricians in the English mining industry for passing the recently-made requirement that they pass an examination to qualify for their positions. That explains its title, "Mining Electrical Engineering." "Practical Electrical Engineering" would be a better title, for it is just as good a book of instruction for men who operate or maintain electrical machinery in other industries as it is for the mining electricians.

The book treats all branches of electrical equipment; and the treatment of each branch is clear, concise, graphically presented. Examples worked out in detail, illustrating what few mathematical relations the book contains, help to "bring the subject home." The chapters on power and alternating currents are particularly good for this method of making the reader at home with the basic quantities in electricity and their significance.

Considerations entering into the choice of equipment for different industrial requirements are gone into considerably, and requirements of operation discussed, thereby making the book helpful in the selection and installation of electrical equipment. For instance in treating motors, not only are the theory and characteristics of motors presented, but the suitability of each type for different plant operations is well discussed. Operation and service requirements are kept prominently in mind throughout the book, as evidenced by the detailed consideration given to electrolysis in cables. Many illustrations of electrical equipment construction, large enough to present details clearly, are also of great help in understanding the care and operation of electrical machines.

A general treatment of instruments and a similar one on illumination help toward making the book complete. Help so much in fact that one wishes the author had included a chapter on circuit breaking equipment or "switchgear." This branch of electrical equipment is simple in principle, but the great variety of types and constructions in use makes them a large and important item in the electrician's field.

The readable print, bold-facing of important terms, and numerous illustrations make reading of the book easier and more instructive.—H. Olken. (4.2) **B**

terminations of the factor, *f*, should be made in conjunction with the rating of meters which are to be used in turbulent water.

The measurements taken by Haskell meters are not comparable with those taken with the other meters for which results are shown. The reader needs to be cautioned not to fall into the error of assuming that the Haskell meter, if used in the same manner as the other meters, would over-register—as the diagram indicates—to substantially the same extent as the Price meter. The contrary is the fact as shown at the end of the section entitled "Effect of Fluctuations in Speed of Flowing Water." Had the Haskell meter been operated to register every fifth or tenth revolution, as was the case with the other meters, it would have shown very little over-registration and would have given results agreeing with those for the Hoff and Ott meters.

By Richard Van Vliet, Ass't Eng. with R. E. Horton:

[Referring to results of numerous experiments in Great Britain]

1. The error in registration was dependent on the position of the meter with reference to the sides of the channel.

2. The error in registration caused by the obliquity was greater in a small channel than in a large channel.

3. The results showed a smaller error in registration for a shielded meter, such as the Stoppani, than for an Ott or an Amsler meter.

4. Where considerable turbulence exists, a meter of the Price type will give results in excess of the true value. On the other hand, a meter of the screw type will give results which are deficient as compared with the true value.

By Dr.-Ing. L. A. Ott, Math. Mech. Institut, Kempten, Bavaria, Germany:

. . . In July, 1929, comparative discharge measurements by various methods (the Allen salt-velocity method, the Gibson method, with Pitot tubes and Ott current meters) were undertaken in one of the penstocks of the Walchenseewerk under the impartial management of the Research Institute for Hydraulic and Hydro-Electric Structures in Munich. The measurements proper were carried out by experienced German and English crews. The results clearly showed the superiority of the current meter for this very kind of gaging. . . .

CHAPTER XXV—HEAD METERS

ADDENDUM TO § 11 ON INSTALLATIONS

The following matter, based on important research data communicated to the author by L. K. Spink, Mgr. Flow Meter Div., Foxboro Co., will appear as § 11, Art. (b) in this Handbook when printed in book form, and the other articles of that section re-lettered: (b) will be (c), etc.

Checking up recently on the A.G.A. and similar recommendations, L. K Spink of the Foxboro Co., finds "that downstream disturbances more than three pipe diameters from the downstream pressure tap could be neglected in their effect on flow measurement. On the other hand, regulators, valves, swing connections, etc., have an appreciable effect on the orifice coefficient as far upstream as fifty pipe diameters." From a set of eleven blueprints giving Spink's results in graphic form, Fig. 25-55 has been made up to show the most significant of his findings.

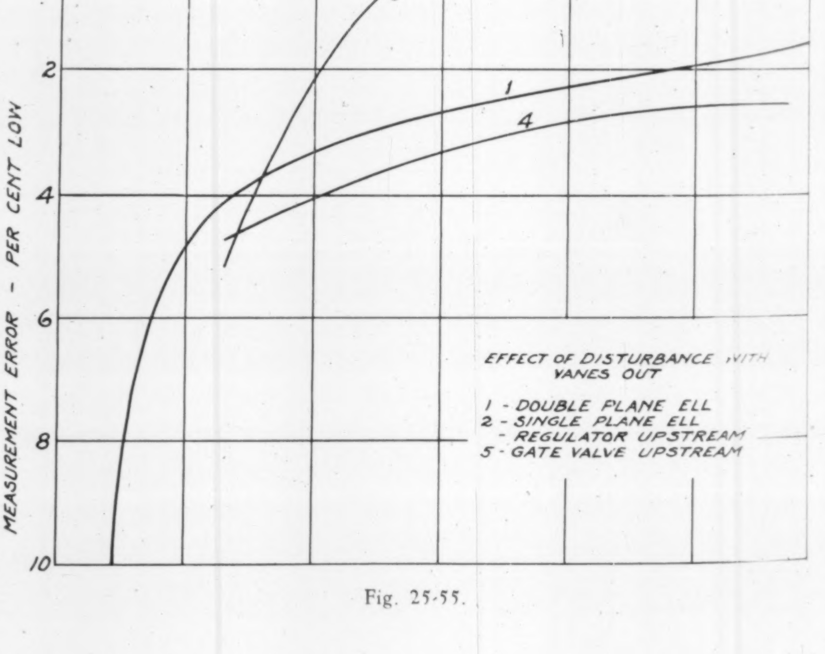


Fig. 25-55.

NEW INSTRUMENTS

Recently Developed by Manufacturers

Write Information Section, Instruments Publishing Company, for additional Information.

New Line of Recording Flow Meters

Neilan Co., Ltd.

GENEROUS use of stainless steels and a unique concentric-tube manometer are among the features of this newest line of flow meters. The primary elements are standard orifices, etc., and this announcement therefore describes only one of the instruments, the 2-pen recorder. The construction is shown in Figs. 1, 2 and 3 and is explained in the captions.

Standard differential ranges are 20, 50 and 100″ water head. Changes are effected by changing manometer tubes (part 3, Fig. 2). These are of genuine Nirosta "KA2." This material assures accuracy in metering, because of its corrosion resistance and because fluid seals of any kind may be used without the usual building up on the walls. It lends itself to an even mercury meniscus, and after any length of service may be quickly cleaned to the original smoothness.

Also of KA2 is the check-valve and stem assembly (part 9, Fig. 2). The arrangement is such that the entire weight of the float seats securely, and the valves gain proportionately greater power as the differential increases.

In Fig. 1, part 2 is an adjustable orifice, connecting the two mercury columns, for dampening pulsations; and is so designed as to be adjustable without mercury loss when the meter is in operation.

Similarly to the idea of the concentric manometer tubes, the coil assembly (part 4 in Fig. 1) is mounted so that its drive is taken from the same center of rotation as the manometer indicating pen, eliminating any offset mechanism and reducing the number of parts. Complete flexibility for calibration is provided, the coil clamp being movable over the face of the coil which may be rotated on its base.

Fig. 3 shows, half actual size, the stainless steel compensator assembly (part 10, Fig. 2). The small adjusting screw governs rate of compensation, so that the meter may be instantly calibrated throughout its range. The displacement of the manometer tubes is such that the float gives this element a total movement of 39° through the indicating range. Correct indication is guaranteed by the sturdy reset device. Irrespective of the position on the chart the indication is automatically corrected by the shortening or lengthening of the radius of the rotating element arm.

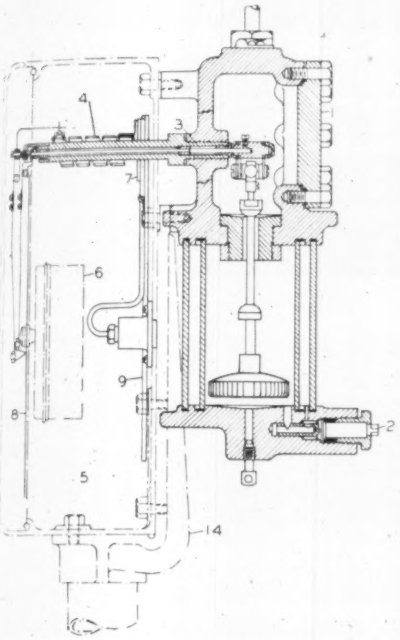


Fig. 1

1. Inspection plate
2. Adjustably restricted connection for damping pulsations, has a positive metal-to-metal seat forelocking when final adjustment is made.
3. Pressure-tight bearing and grease seal assembly. Hardened molybdenum alloy shaft carried on a three-bushing suspension, center bushing ground and tested for leakage. Between center bushing and internal bushing a 1″ body of grease provides further seal and at same time eliminates friction.
4. Coil assembly actuating line pressure pen.
5. Cast Duralumin case, rubber gasketed throughout for moisture proofing.
6. Clock (electric or spring wound). 1-hr., 24-hr. or 7-day movement. Clock, chart plate and coil assembly mounted on steel back plate bolted directly to mercury chamber to eliminate temperature effects on record.
7. Pen assemblies; micrometer adjustments; pen arms removable from hub.

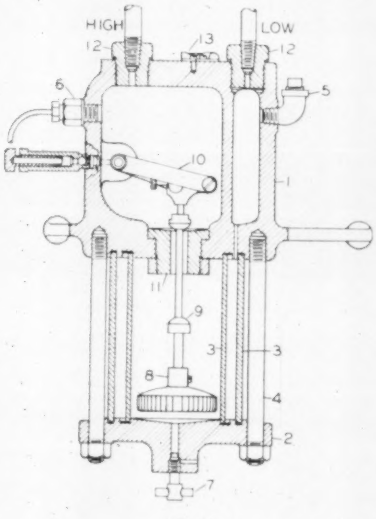


Fig. 2

1. Manometer head. Cast iron to 500 lbs. working pressure; steel to 1,000 lbs. Both high and low pressure chambers contained in casting, bottom being fitted with a series of grooves to allow changing range.
2. Manometer base, also of cast iron or steel construction and fitted with grooves corresponding to those of the head.
3. Manometer tubes, of rolled and drawn Nirosta KA2 stainless steel, machined and ground to within 0.002″.
4. Manometer through bolts, heat treated molybdenum steel.
5. Filler plug.
6. Removable static pen connection. May be used or not depending on fluid metered.
7. Drain plug for removing mercury.
8. Unusually large steel float.
9. Check valves and stem assembly, of KA2 stainless steel to eliminate corrosion.
10. Compensator assembly, also of stainless steel.
11. Check valve seat assembly, inset and of stainless steel.

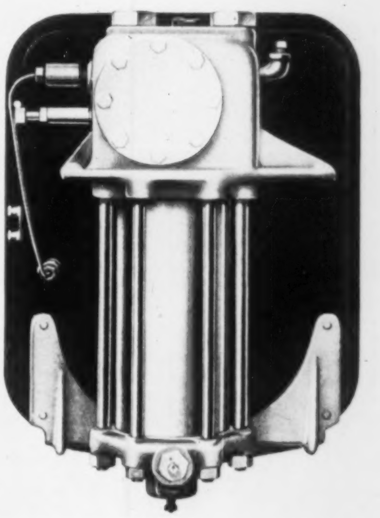


Fig. 5

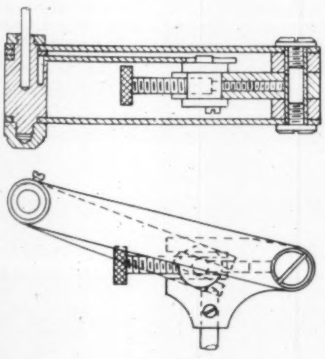


Fig. 3

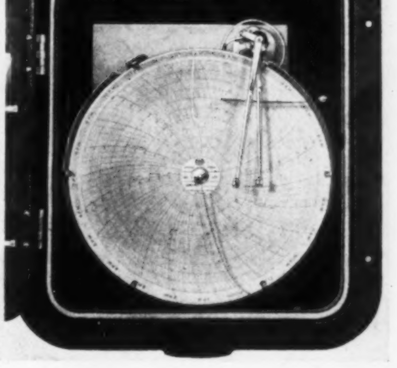


Fig. 4

"Chronoflow" Electrically Operated Remote-reading Fluid Meters

Builders Iron Foundry

ACCURACY of measurement and of integration at low rates of flow is one of the characteristics of a new line of fluid meters designated as "Chronoflo." This name signalizes the principle employed, i. e., measurement of flow in terms of time, by means of a Telechron-driven contact device in the manometer unit, the operation of which is shown by Figs. 1 and 2.

Figs. 3 and 4 show a typical "Chronoflo" panel-board instrument—a combined recorder and integrator. The characteristics of the transmitting manometer and of the electrical circuit are such that chart records are reliable to 1/12th of the maximum rate and that totalizations are accurate at 1/20th of the maximum rate. Panel-board instruments have hexagonal cases with long side hinges permitting mounting all working parts on a single plate which can be swung out from the case for easy inspection.

Manometer units can be connected to Venturi tubes or orifice plates and are furnished for maximum differentials of 40, 60, 120 or 240 inches of water. "Chronoflo" meters are applicable for steam, air, gas or liquids, especially where there are wide seasonal or day-and-night or hourly variations in the rate of flow.

There are no limits to the distance allowable between the pipe line and the panel-board instruments: for exceptionally long distances the standard public telephone system circuit can be used.

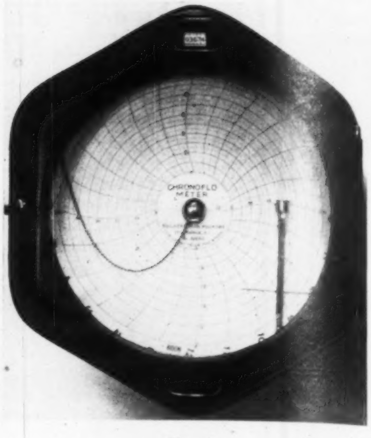


Fig. 4

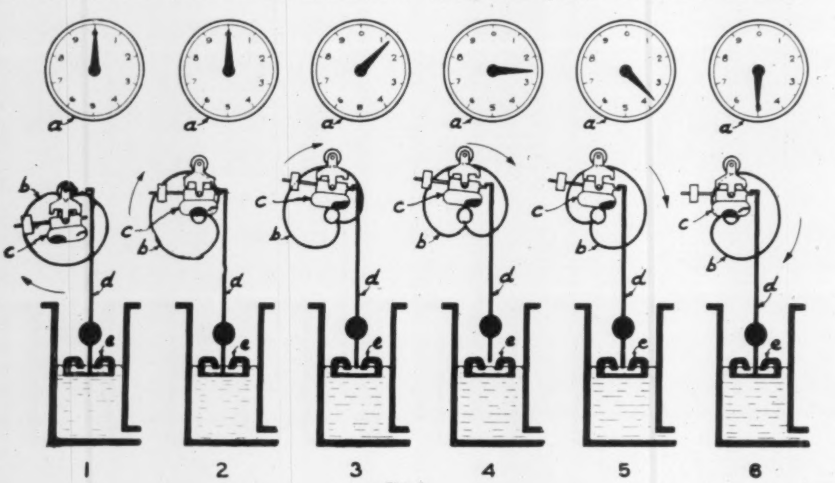

a
b
c
d
e
1
2
3
4
5
6

Fig. 1

(a) is a Telechron driven register; (b) a square root cam driven by another Telechron; (c) a mercury switch so mounted that it travels up and down following the contour of cam (b); (d) a freely moving, properly guided switch tripping rod positioned by the float; and (e) monel float on mercury surface rising and falling as the flow increases or decreases. Register (a) is designed to add ten units per minute (per revolution of dial hand) at maximum rate and registers continuously at that rate, when float is in lowest or maximum rate position. In this diagram the float is assumed in its half rate position, and registration takes place during 30 seconds of the minute cycle.

Position 1. (0 and 60 sec.). Dial (a) shows zero and cam (b) is at start of its cycle.

Position 2. (15 sec.). Dial (a) still shows zero; mercury switch (c) is just being tripped by (d).

Position 3. (22½ sec.). Dial (a) registers 1.25; (c) circuit is still made, (d) rises from float (e), carried by switch (c).

Position 4. (30 sec.). Dial (a) registers 2.5; switch (c) reaches maximum height of cam (b) with circuit still made.

Position 5. (37½ sec.). Dial (a) has continued to 3.75; (d) is lowered with (c) approaching float (e).

Position 6. (45 sec.). Dial (a) reaches 5; (d) touches float, breaks circuit in (c) and registration stops. Cam (b) continues its cycle and repeats when Position is again reached.

This illustration is typical of any intermediate flow position. The mercury unit is so designed that at zero differential the mercury switch is never tripped; preventing any dial registration; and at maximum flow the circuit is made during the entire cycle. Changes of rate of flow during the cycle shorten or lengthen the period of contact, producing corresponding registration.

Fig. 2

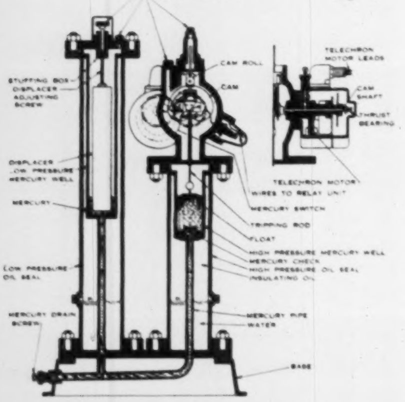
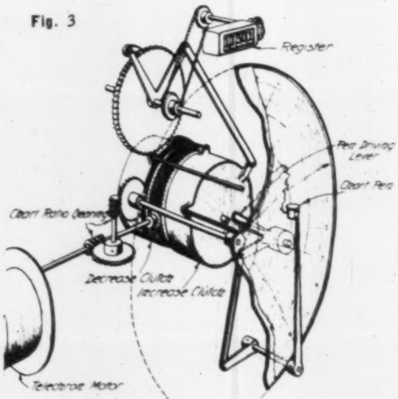

DISPLACER ADJUSTING KNOB
FILLING HOLE PLUGS
STUFFING BOX
DISPLACER ADJUSTING SCREW
CAM ROLL
CAM
TELECHRON MOTOR LEADS
CAM SHAFT
THRUST BEARING
DISPLACER
LOW PRESSURE MERCURY WELL
MERCURY
TELECHRON MOTOR
WIRES TO RELAY UNIT
MERCURY SWITCH
TRIPPING ROD
FLOAT
HIGH PRESSURE MERCURY WELL
MERCURY CHECK
HIGH PRESSURE OIL SEAL
INSULATING OIL
LOW PRESSURE OIL SEAL
MERCURY DRAIN SCREW
MERCURY PIPE
WATER
BASE

Fig. 3


Register
Pen Driving Lever
Chart Pen
Chart Ratio Gearing
Decrease Clutch
Increase Clutch
Telechron Motor

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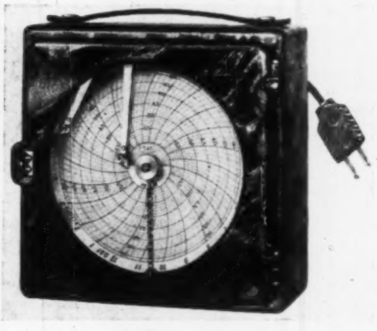
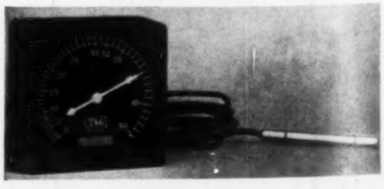
Miniature Recording and Square Case Dial Indicating Thermometers

C. J. Tagliabue Mfg. Co.

THE need for low cost, portable indicating and recording-devices for refrigerator manufacturers and distributors has been met with the development of these two new instruments. The new TAG Recorder, in performance, duplicates its larger brothers, lacking nothing of their sturdiness because of its miniature size: 5¾" and weighing but 3½ lbs. This recorder is also supplied in a two-pen model for recording the idling and running time periods of the motor, on the same chart with the temperature record.



Specially designed to indicate almost instantaneously the temperature of evaporators, the new TAG Square-Case Dial-Indicating Thermometer enables the service men to observe rapid changes in temperature and thus assures accurate settings of expansion valve and thermostat. Due to its light weight (less than 1¾ lbs.) and its extremely small size (4" square) it can be readily carried with other equipment by inspectors and service men.



The New Brown Mechanical Flow Meter

By **Thomas R. Harrison***

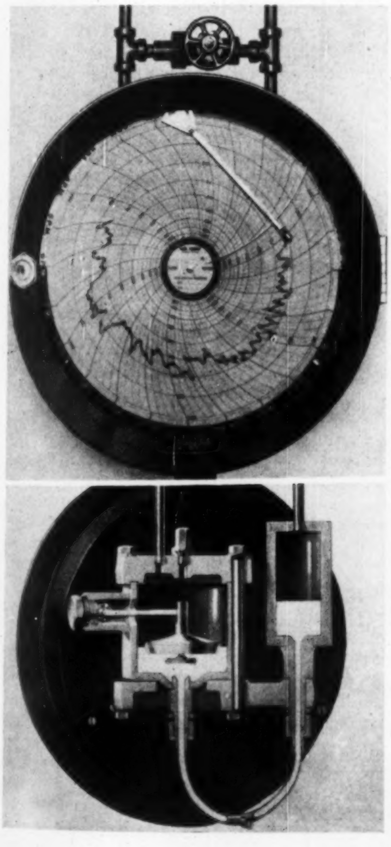
THE Brown Instrument Company has rounded out its line of fluid measuring instruments by the addition of a series of mechanical flow meters. It is mentioned here as a series because the new flow meter has been developed in combinations including:

1. Square root and evenly divided charts.
2. Automatic planimeter.
3. Multipen: flow–pressure–temperature.
4. Compensation for pressure and temperature.
5. Automatic control and recording.

This new line is featured by a simple direct lever-actuating mechanism, large powerful float, pressure-tight bearing with grease reservoir, a series of range tubes that permit changing the range of the meter without disturbing the orifice, and construction permitting the manometer to be taken apart and cleaned in the field without altering the calibration.

The model illustrated is representative of the entire new line. The high-pressure chamber—a drawn steel cup—and the low-pressure chamber or range tube—seamless steel tubing—are connected by a steel U-tube provided with a drain plug. A forged steel tee-fitting welded to the side of the high-pressure chamber provides a means for mounting the pressure-tight bearing in a position for attaching the float lever on one end and the pen linkage on the other.

There is no relative motion between the float and mercury surface, hence the mercury level is accurately transmitted to the instrument movement. The linkages are simple and direct. The relative positions of the float and pen linkages are fixed by flats on the pressure shaft and the lengths of the links. Thus it is possible to drain the mercury, open, clean and reassemble the manometer, add enough mercury to bring the pen to zero, and calibration is unchanged.



The linkage of the square-root-chart meter differs from that of the uniform-chart meter in that in the latter the float motion is transmitted through a pair of cams making the pen travel proportional to the square root of the float movement. The cams roll on each other, eliminating sliding friction. In order to keep the magnification factor between float movement and pen travel within practical limits, the evenly divided flow chart is made evenly divided from 100% of full scale down to 10% of full scale and square root from 10% to 0. The theoretical and actual zero lines both appear on the chart. In the case of multi-pen instruments, pens other than the flow pen start from the theoretical flow zero since they do not involve an infinite magnification factor as they approach zero. Thus one set of divisions can be used for flow, temperature and pressure.

All recorder models use 12″ charts regardless of whether the chart is of the evenly divided type or of the square root type.

The shaft bearing is pressure-tight by virtue of the precision with which it is made. Grease acts both as a lubricant and a sealing medium as the pressure inside the manometer forces it from the reservoir to surround the shaft. Every shaft is fitted individually in its bearings. A pivot ground on the outer end of the shaft bears against a hardened flat plate to take up the thrust resulting from the higher pressure within the manometer. The full-scale rotary motion of the shaft is about 22 degrees. When the float goes beyond full scale, a disk carried under it seals the high pressure chamber against mercury blow-out.

Multi-pen models, in addition to making a record of the flow, pressure and temperature, have been developed so that compensation for variations in the pressure and temperature of the fluid being measured can be automatically applied to the flow pen. That is, all multi-pen models are not provided with automatic compensation, but compensation for either one or both can be incorporated. Compensation is accomplished by varying a sensitivity lever between the manometer float and the flow meter pen automatically by means of a lever between the pressure or temperature responsive element and sensitivity lever. In cases of double compensation, that is, compensation for both temperature and pressure, the two variables are combined to give a net effect and this single net effect is applied to the movement of the sensitivity lever.

All recording models can be provided with either hand-wound or electric chart drive in a variety of chart speeds. The hand-wound clock, with its chromium-plated, stainless steel, and cadmium-plated parts, is protected by a dust-proof case. The electric clock, a radical departure, is driven by a 60 r.p.m. synchronous motor.

Models incorporating automatic recording planimeters and totalizers carry a sector on the pen shaft. The shape of this sector depends upon the type of chart used. An integrator arm contacts the sector every six seconds and a clutch engages the driving motor to operate the totalizer which is a five-digit counter, and as each figure is brought into position it is recorded on a set of vernier graduations at the edge of the chart by means of an auxiliary pen. Thus, a record of both the rate of flow and the total flow is made on the chart. The power required for the integrating mechanism is obtained directly from the motor. Where electric power is not available a spring-driven clock operates the integrator once a minute.

Control models, in single and duplex forms, operate mercury switches and handle 15 amps. at 110 volts without relays. A control segment is carried by the pen. The control mechanism locates the position of the control segment every six seconds and the mercury switches are tilted as required. The duplex control mechanism is used on two-pen instruments and will automatically control two variables. Combinations of flow with either temperature or pressure can be furnished in the duplex control models. In addition to commanding motorized valves, pumps, etc., control instruments may sound alarms or flash lights.

Easily changeable range tubes facilitate shifting all models from one job to another without disturbing existing orifice elements. Any model may be mounted on a floor stand, wall bracket, or pipe saddle. The new type die-cast case permits flush mounting on a panel. The instrument is as light as is consistent with a working pressure of 1000 lbs., and is portable in that it can be carried from one job to another.

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[*] Director of Research, The Brown Instrument Company.

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High Water Alarm

Square D Company

TO the line of pressure, float, and vacuum switches manufactured by the Industrial Controller Division of this company has been added a new high water alarm for use over sump or open tanks, which sounds a warning when the liquid reaches a dangerously high level. This inexpensive device, which may prevent serious flood damage, consists of a single-pole pressure switch, a transformer, and signal bell, wired in one unit and mounted on a 1″ pipe. A rising column of liquid in the pipe exerts air pressure on the diaphragm of the switch, closing a contact and ringing the bell. Signal continues until the liquid level has been lowered.

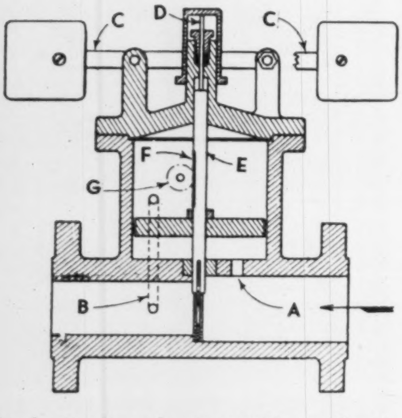
Variable Area, Constant Head Flow Meter for Liquids

The Isometer Company

ALTHOUGH novel in details of construction, this new liquid flow meter, the Isometer, employs an old principle, the dependability of which has been demonstrated in numerous European and American fluid meters of the "area" or "geometric" class. This principle is the maintenance of a constant head by automatically proportioning the orifice area to the rate of flow. In the Isometer the work of constantly varying the orifice area is performed by a cylinder-and-piston device which develops "tremendous" power when the metered fluid is under sufficient pressure, as is the case, for example, on a boiler feed water metering installation. No electric motor or other form of auxiliary power is required, and the Isometer is said to be particularly applicable to the measurement of pulsating flow.

The standard Isometer consists of an actuator (illustrated) located in the pipe line; and of a meter made in three styles: (1) indicating; (2) indicating and integrating; (3) indicating, integrating and chart recording.

The action is as follows. The upstream pressure is applied to the lower side of the floating piston through port "A." The downstream pressure is applied through tube "B" to the upper side of the floating piston. This piston is under constant downward mechanical load equal to the desired differential head. The orifice opens or closes until the downstream pressure force, above the piston, combined with the mechanical load, equals and opposes the upthrust resulting from the upstream pressure below the piston. It maintains this relation exactly, following instantly any change in flow.



The constant mechanical load on the piston is obtained from two weighted lever arms "C" and transmitted to push rod "D" which extends through a packing nut and seats on the upper end of piston stem "E."

Mounted on the stem is rack "F" whose full movement turns gear "G" and its shaft through 140 deg. The shaft is brought through the cylinder wall and its motion is transmitted to the indicator hand of the instrument. In the remote type meter, this connection is made by a special flexible shaft.

The Isometer is built in eight standard sizes ranging from ¾ in. to 4 in. and from capacities of 10 gallons per minute (5,000 lb. per hour) to 250 gallons per minute (125,000 lb. per hour). Standard designs are available for pressures of 125, 250, 400 or 600 lb. per sq. in. and are fitted with the corresponding A.E.S.C. flanges.

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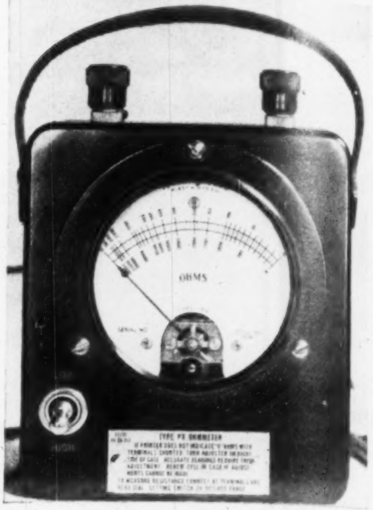
Direct Reading Ohmmeter

Westinghouse Electric & Mfg. Co.

THIS new double-range ohmmeter is a self-contained instrument which requires no external source of voltage and measures ohms as directly as a voltmeter measures volts. The resistance ranges of 5000 and 50,000 ohms are selected by flipping a toggle switch. The instrument requires such minute current that the useful life of its supply (an ordinary 1.5 volt flashlight cell) corresponds almost to "shelf life." There is an adjustment, on the side of the case, for change in cell output so that accurate readings are always possible.



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Continuous Automatic Smoke Density Meter

Brown Instrument Company

EASY to install and requiring minimum attention, this new device measures the density of smoke in flue gases by electro-optical means. A portion of the flue gas is made to pass between a source of light and a light-sensitive device. As the smoke density varies, the amount of light falling upon the light-sensitive device also varies, and the resulting current variation from the photo-cell is transmitted to the indicating or recording meter. The chart of the recording instrument is calibrated to read in percent smoke density. The indicating scale may read in percent or in Ringelmann chart numbers.

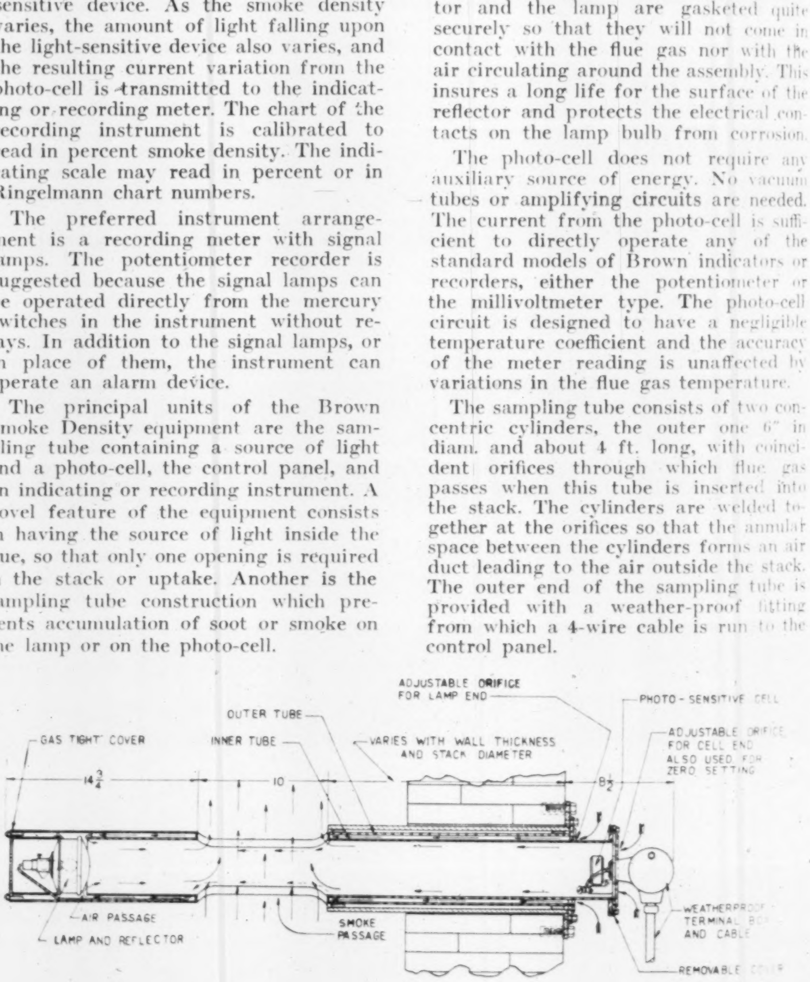
The preferred instrument arrangement is a recording meter with signal lamps. The potentiometer recorder is suggested because the signal lamps can be operated directly from the mercury switches in the instrument without relays. In addition to the signal lamps, or in place of them, the instrument can operate an alarm device.

The principal units of the Brown Smoke Density equipment are the sampling tube containing a source of light and a photo-cell, the control panel, and an indicating or recording instrument. A novel feature of the equipment consists in having the source of light inside the flue, so that only one opening is required in the stack or uptake. Another is the sampling tube construction which prevents accumulation of soot or smoke on the lamp or on the photo-cell.

The light source consists of a small electric light bulb at the focal point of a parabolic reflector. The bulb, especially made for use in high temperatures, is operated at less than its rated wattage and accordingly has a life of several months' continuous service. The reflector is chromium plated and both the reflector and the lamp are gasketed quite securely so that they will not come in contact with the flue gas nor with the air circulating around the assembly. This insures a long life for the surface of the reflector and protects the electrical contacts on the lamp bulb from corrosion.

The photo-cell does not require any auxiliary source of energy. No vacuum tubes or amplifying circuits are needed. The current from the photo-cell is sufficient to directly operate any of the standard models of Brown indicators or recorders, either the potentiometer or the millivoltmeter type. The photo-cell circuit is designed to have a negligible temperature coefficient and the accuracy of the meter reading is unaffected by variations in the flue gas temperature.

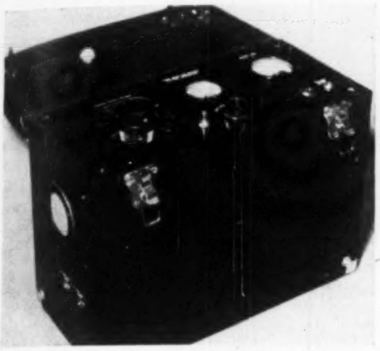
The sampling tube consists of two concentric cylinders, the outer one 6" in diam. and about 4 ft. long, with coincident orifices through which flue gas passes when this tube is inserted into the stack. The cylinders are welded together at the orifices so that the annular space between the cylinders forms an air duct leading to the air outside the stack. The outer end of the sampling tube is provided with a weather-proof fitting from which a 4-wire cable is run to the control panel.


ADJUSTABLE ORIFICE FOR LAMP END
OUTER TUBE
PHOTO - SENSITIVE CELL
GAS TIGHT COVER
INNER TUBE
VARIES WITH WALL THICKNESS AND STACK DIAMETER
ADJUSTABLE ORIFICE FOR CELL END ALSO USED FOR ZERO SETTING
14¾
10
8½
AIR PASSAGE
LAMP AND REFLECTOR
SMOKE PASSAGE
WEATHERPROOF TERMINAL BOX AND CABLE
REMOVABLE COVER

Portable Noise Meter

E. E. Free Laboratories

TYPE-123 Noise Meter has been developed to meet the need for a rugged, inexpensive, easily portable and highly flexible instrument for the accurate measurement of noise or other sound. It is self-contained, independent of outside electric supply and can be operated as easily as a voltmeter or a thermometer. It consists of a dynamic microphone, a 3-stage amplifier, an electric meter and the necessary dry batteries, contained in a leather-covered case 17 x 13 x 8 inches. The carrying weight, complete, is 33 lbs.



The microphone converts the sound waves to be measured into an electric signal, which then is amplified in a known ratio and measured on the electric meter, reading directly in decibels. One reading of noise intensity, including all adjustments of the instrument, can be made in less than 1 minute. Repeated readings in one location require less than 10 seconds each.

The instrument is calibrated in the decibel scale. The range is from 30 db. to 120 db. (A noise of 30 db. is about that of the average quiet residence in the country; 120 db. is above that of an unmuffled airplane engine 5 feet from the ear.) For convenient measurement of rapidly varying noises, such as street noise or machine noise, the decibel meter is damped to an average period of 1/3 second. Neither the amplifier nor the decibel meter can be burned out or damaged by overloading due to loud noises.

Response to sounds of different pitches corresponds approximately to that of the average ear for moderate intensities between 60 and 3500 cycles per second. At about 500 cycles the instrument is slightly more sensitive than the average ear. Between about 2000 and about 2500 cycles it is slightly less sensitive. At frequencies much above 3500 the response of the standard instrument is unsatisfactory. For the measurement, therefore, of squeaks, very shrill whistles or other high-pitched sounds the instrument is recommended only if equipped with a special microphone sensitive to high frequencies, as described below.

Extreme flexibility is a characteristic of the Type-123 Noise Meter. Any type of microphone or other pick-up device, or any type of electric filter or frequency analyzer, may be used at the input. The output jack may be used similarly to attach any type of indicating or recording meter, oscillograph or other high-grade acoustic or electric instrument. By using the input and output jacks, the noise meter may be used as a self-contained amplifier for general laboratory purposes, having a constant power gain of 70 decibels and an exceptionally flat frequency characteristic.

Accessories—A separate microphone can be provided for use inside soundproof boxes for factory inspection operations, or when it is convenient to place the noise meter itself in one position and to move a small microphone to different parts of a room, a machine or other test operation. The noise meter is provided with an input jack of 20-ohm impedance for the attachment of this separate microphone. This jack, when used, automatically disconnects the microphone in the instrument itself.

A condenser transmitter or other high-quality microphone, with its necessary head amplifier, may be attached by means of a second input jack having 6000 ohms impedance. When used in this way with a Western Electric condenser transmitter or other microphone of equivalent quality, the frequency response of the noise meter is uniform and correct to less than 2 decibels between 60 and 10,000 cycles. Thus equipped, the meter is believed to be equal or superior to any other sound-measuring instrument now available.

A pre-amplifier and sensitive microphone can be provided for the measurement of sounds below 30 decibels in intensity; and a pre-attenuator for the measurement of sounds above 120 decibels. A recording meter can be attached, if desired, to keep a continuous record of sound intensities. The reverberation meter, Type 116-A, can be attached to measure the reverberation time of rooms. An electric pick-up for mechanical vibrations or for noise from limited areas, such as one gear, can be supplied for use in the same manner as a separate microphone.

Electric frequency analyzers, Types 125-A or 125-B, can be used between the noise meter and a separate microphone, to separate and measure, by octaves between 32 and 8196 cycles, the different frequencies in a complex sound. One or more of special ear filters may be used similarly to make the readings of the instrument agree with the loudness judgments of the average human ear for the faintest audible sounds, or for any other average loudness, as determined by Kingsbury and others. Special electric filters can be designed and supplied for the separate measurement of any specified frequency or frequency band.

Any type of oscillograph or oscilloscope may be attached by means of the output jack provided. Automatic warning signals, governors or inspection controls can be attached to operate any type of control or alarm if a noise intensity exceeds a predetermined value.

Decibel meters can be supplied with dials carrying a red line or other mark to indicate that a predetermined inspection tolerance is exceeded. Attachments for quick change of such tolerance can be supplied.

Weston meters and Amertran transformers are used throughout. All other parts and all workmanship are of the highest obtainable quality. A complete set of tested tubes, as free as possible from microphonic noises, is supplied with each instrument; as is a set of Burgess dry batteries. A combined ammeter and voltmeter, with control rheostat, conveniently checks the battery voltages. An automatic switch, operated by closing the case, minimizes risk of running down batteries.

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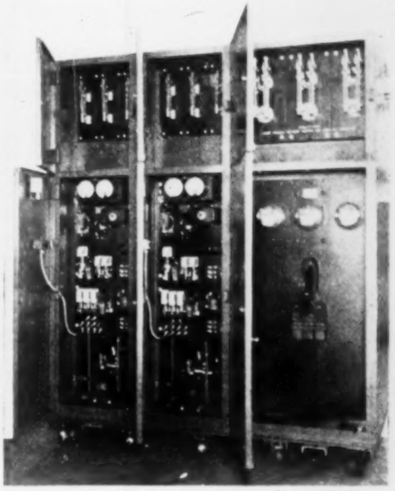
Synchronous Motor Starter Protected From Dust

Westinghouse Electric and Mfg. Co.

ENTIRELY enclosed in cubicles for protection against dust, a synchronous motor starter recently built and shipped from the East Pittsburgh Works has 3 compartments: one contains an incoming line circuit breaker with disconnect switches, while each of the others houses on individual synchronous motor starter with an electrically operated breaker and an individual disconnect switch. Each is provided with a lock. Starting and stopping the two motors is accomplished from a remote push-button station. The individual motor generator exciters are controlled from the same push-button that starts the synchronous motor.



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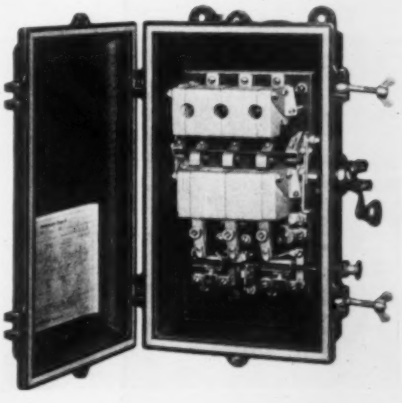
New Combination Units for Starting A.C. Motors

Square D Company

COMBINATION starters of water- and dust-tight construction in the cast iron type have been added to this company's line of a. c. starters. The apparatus is intended for installation in damp or dusty locations and corrosive atmospheres such as found in flour and starch mills, cement plants, foundries, packing plants, and similar places. This equipment is not explosion proof. The unit consists of an across-the-line starter, motor control switch, and test jack. Thermal overload protection and low voltage protection are provided. Starters are built in two sizes known as Class 8532S and 8536S, and can be furnished fusible or non-fusible. The cast iron cabinet has machined flanges and rubber gaskets to exclude moisture and dust.



Askania Radiation Primary Element Temperature Control Systems

H. A. Brassert & Co.

BECAUSE there is no reaction whatever on the jet pipe of the Askania Jet Pipe Relay, this remarkably flexible pilot device can be actuated by what is in effect a sensitive "galvanometer." Accordingly, a line of temperature control systems is now available in which the thermal systems comprise either a radiation-receiver or a thermocouple as the primary element. A radiation receiver is preferable for this purpose. It is more permanent and less likely to suffer damage and derangement from high temperatures. It is better able to give a strong correcting impulse in the case of any variation from the selected temperature, because the impulse varies with the fourth power of the absolute temperature, while with thermocouples it varies directly. There is also less lag than with shielded thermocouples. Finally, with the radiation pyrometer there can be a considerable area of radiating surface.

The diagram shows the high-temperature controller applied to regulating the temperature of furnace atmosphere. It may equally well be used to control the temperature of material which is being heated, as, for example, blooms or billets in a reheating furnace. In such cases regulation of the temperature of the billet next in order to be pushed from the furnace is effected. If for any reason the temperature of the material which is heated is not the important factor and the flame temperature is to be regulated, it is advisable to build into the combustion chamber a radiation tube of ceramic material, the end of which is at the focus of the instrument, as shown. The method employed for fuel regulation for large industrial furnaces is shown in the diagram. 1 shows a section through a furnace, 2 is a ceramic tube from which the heat radiates to the radiation receiver shown at 3. The current passing through leads 4 to coil 5 is proportional to the fourth power of the temperature within the furnace. Any variation from the assigned temperature therefore produces a strong correcting impulse. In the regulator 6 the electrical impulse communicated to the leads 4 is transformed into a pressure impulse. This is done by means of jet-pipe 10 which is in this case operated with air instead of oil.

The air furnished by fan 7 passes into and through jet-pipe 10 and discharges into the orifice 11, the regulator having in this case but a single orifice and orifice pipe. Continuous with the jet-pipe, and rigidly connected to it is arm 12 which carries coil 5. This coil floats within the field of permanent magnet 13.

As the temperature increases and with it the flow of current in coil 5, the latter is repelled by the permanent magnet, moving jet-pipe 10 so that it tends to register more exactly with the orifice 11. This creates a higher pressure on diaphragm 14 which tends to balance the impulse transmitted to jet-pipe 10 by coil 5 and in this manner to act as a stabilizer and to prevent hunting. The impulse of the air from the jet-pipe is also transmitted through pipe 15 to diaphragm 16 where it actuates the jet-pipe of an Askania constant pressure regulator in opposition to spring 17. This constant pressure regulator operates to close valve 18, thereby reducing the supply of liquid or gaseous fuel to the furnace.

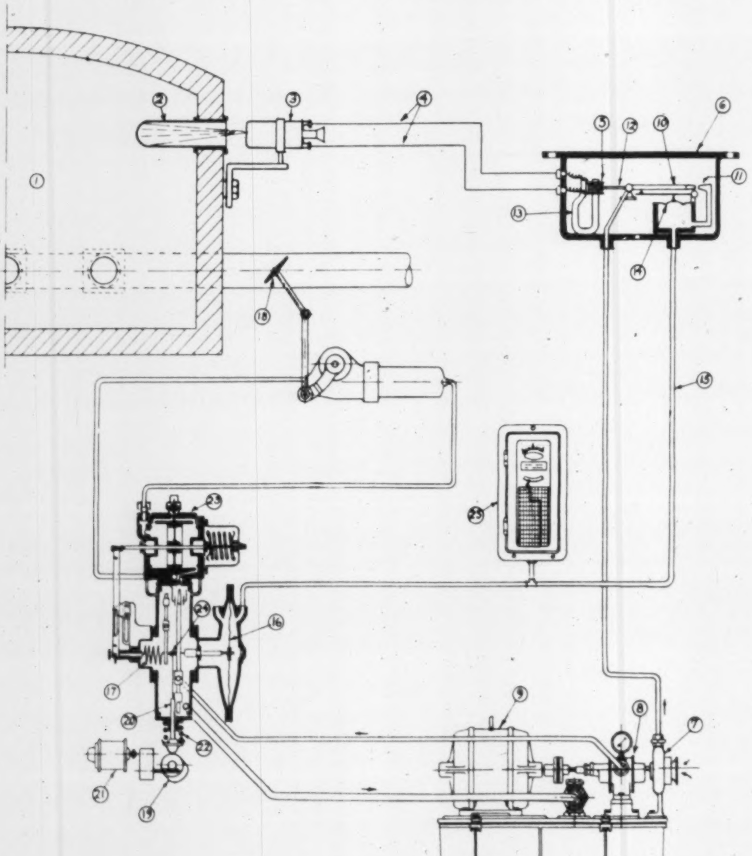
In the event of a drop in furnace temperature the process above described is reversed.

Adjustment of the furnace temperature is effected by means of the spring 17. An increase in the pressure of this spring against the jet-pipe requires an increased air pressure within pipe 15 and against diaphragm 16 in order to restore equilibrium. This requires a more nearly exact registration of the jet-pipe 10 with orifice 11 which is effected by a movement of coil 5 away from the magnet, this movement being produced by higher temperature.

A stabilizing element to prevent hunting is included in the installation, shown as back motion piston 23.

Adjustment of the furnace temperature may be made automatically by means of shaped cam 19 which is held in contact with the head of sliding pin 20 and is rotated by means of clockwork 21. The change in radius results in a different position of disk 24 and therewith of the jet-pipe, and in varying the temperature of the furnace accordingly. The head of sliding pin 20 is held in contact with cam 19 by means of spring 22.

For the supervision of the control, temperature recorder 25 is provided, connected to air impulse pipe 15.



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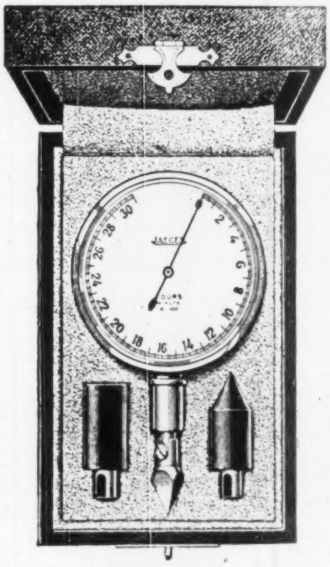
Chronometric Type Tachometer

Jaeger Watch Co.

A UNIQUE and compact chronometric type pocket tachometer recently introduced in the United States can be used regardless of the rotating direction of the machine whose speed is being measured. It is not affected by magnetic fields, weather or atmospheric variations and gives instantaneous readings, making it possible to follow all speed variations. Outside diam. of case, 2⅞"; weight, 7½ ounces.



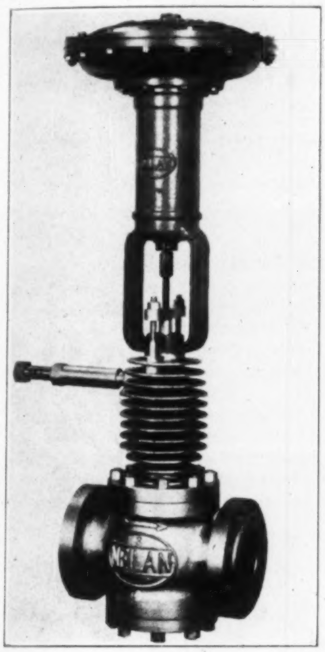
The tachometer is regularly supplied in leather case with one triangular steel point and two rubber points as illustrated, and in three ranges:

Type 1—0 to 1500 turns
Type 2—0 to 3000 turns
Type 3—0 to 6000 turns

Diaphragm-Motor Valve for High Temperature Fluids At High Pressures

The Neilan Company

DEVELOPED specifically for severe service where the flow of fluid at high temperatures and high pressures must be controlled, this air-cooled, grease-sealed, diaphragm-motor valve is recommended for applications in refineries, cracking plants, etc. A series of carefully calculated radiating fins keep the stuffing box so cool that it may be grasped with the bare hand when the valve is passing fluid at 900°F. (though not in the Texas sun). The long stuffing box has a positive gland which prevents the slightest leakage. The company always furnishes the special packing grease most suitable for the thermal and chemical conditions of the individual application.



The upper part is the well-known Neilan diaphragm-motor, an exclusive feature of which is the frictionless ball-bearing stem.

The valve proper has plug guides placed at the top and bottom, insuring minimum obstruction of flow, preventing severe cutting and wire drawing and reducing tendency to "coke up." Nirosta KA2 and Super-Temp steels are generously used. Nitralloy, Bethalon, Monel metal or Ascaloy trim can be furnished.

An idea of the conditions for which these valves are suitable can be had by one example: "Series 150" is for 1200 lbs./in.^{2} pressure at 1000°F.

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New Line of Fractional H.P. Motors

Westinghouse Electric & Mfg. Co.

A RECENT announcement by O. F. Stroman, manager Westinghouse industrial department, tells of the development of an entirely new type of capacitor motor and the redesign of the older types of other small motors. A degree of interchangeability heretofore unapproached in small motor manufacture has been achieved in the new designs. Frames, shafts, bearings and mounting arrangements are interchangeable, rating for rating. Five frame sizes suffice to serve the entire line, ranging in output from 1/30 to 3/4 h.p., whereas more than 100 frame sizes were formerly required.

All types of small motors are affected by the redesign. Split phase, capacitor, repulsion-induction, polyphase, direct current and repulsion motors will comprise the new line. A feature is an improved type of resilient spring mounting to nullify the vibration inherent in all 60-cycle a.c. motors.

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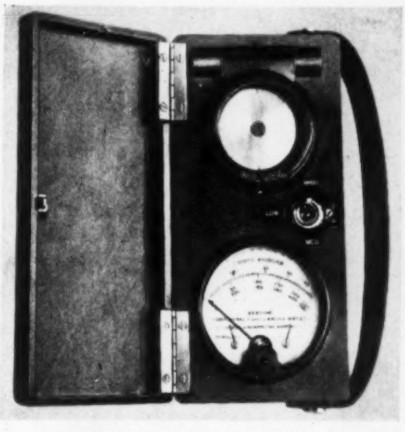
Pocket Size Foot-Candle Meter

Weston Electrical Instrument Corp.

MANY simplified and new photocell applications with relays and indicating instruments have been made possible through the use of the new Weston Photronic Cell. The latest of these applications is a pocket size Foot-candle Meter, built especially for salesmen's use, calibrated to read directly on three ranges: 50, 250 or 500 Foot-candles. One cell is used as an adjustable light collector, with readings appearing on a scale 2.36 in. in length. The cell and instrument are housed in a neat, black, molded case, measuring approximately 3 3/8 x 7 x 2 1/4 in. A hinged cover and convenient carrying handle finish it in attractive form. The Photronic cell housing is hinged, permitting the cell to be faced toward any direction while the outfit is laid on a horizontal surface.



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"SeizO$_2$"

The Hays Corporation

THIS new stable combination of chemicals uses a catalyst to "seize the O$_2$" (hence the name) and an oxidizing agent of enormous capacity to gather in and store it. All Hays gas analyzers are now supplied with "SeizO$_2$" rather than Pyro, and it is now available to the users of Hays analyzers.

One charge of "SeizO$_2$" will remove oxygen from about 500 flue gas samples. "SeizO$_2$," therefore, offers practically the efficiency and capacity of caustic potash with regard to carbon dioxide. The chemical loses its efficiency abruptly when it has reached its capacity. One cc. of "SeizO$_2$" will take up between 50 and 60 cc. of oxygen and it will maintain excellent efficiency until each cc. of the charge has absorbed 47 cc. of oxygen. The best pyrogallic acid solutions absorb 12 cc. O$_2$ per cc. of chemical. Pyro is somewhat unsatisfactory not only on account of its comparatively smaller absorbing capacity, but also on account of the fact that its life is seriously affected by light, and if a week elapses between tests a new charge is generally necessary. "SeizO$_2$" retains its efficiency over long periods.

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New General Purpose Mill Type Starters

General Electric Company

NEW general-purpose mill type starters for constant speed d. c. motors utilize newly developed accelerating contactors designed not only to act as time delay relays, but also to short out the starting resistor by means of a contact finger. The new accelerating contactor, therefore, replaces two conventional devices; namely, the accelerating relay and the old accelerating contactor. The new starters are very sturdy and of unusual mechanical and electrical simplicity, minimizing maintenance cost. The accelerating contactors are equipped with silver-faced tips to eliminate oxidation difficulties where motor operates steadily for long periods. The starters are available in sizes from 1 hp. up to 75 hp. Each starter mounts the following devices:

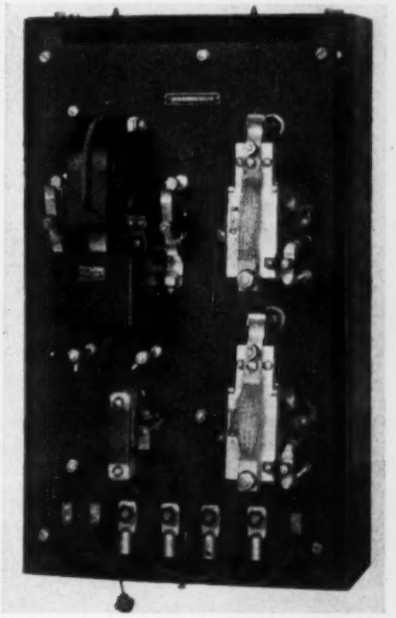
1 Line contactor, equipped with interlock for undervoltage protection (when used with momentary contact start button).

1 to 3 Magnetic time accelerating contactors.

1 Thermal overload relay.

1 Starting resistor.

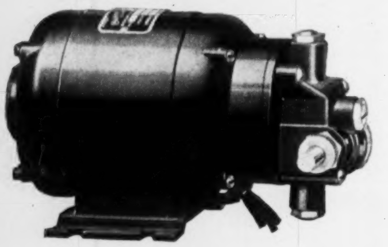
1 Sheet metal enclosing case, ventilated, adapted for wall mounting.



New Fractional H.P. Motors With or Without Speed Reducers

Bodine Electric Company

A NEW line of fractional horsepower motors includes the type NSY-12 self-starting, single phase, synchronous motor in ratings of 1/75 h.p. in the open ventilated frame and 1/150 h.p. in the totally enclosed frame at a motor speed of 1800 r.p.m.; and the type NSI-12 induction motor in ratings of 1/50 h.p. in the open ventilated frame and 1/70 h.p. when totally enclosed at a motor speed of 1725 r.p.m. and 1/100 h.p. in the open frame and 1/150 h.p. when totally enclosed at a motor speed of 1125 r.p.m. Worm gear speed reducers are available with the following ratios: 8½-1; 17-1; 30-1; 35-1; 72¼-1; 144½-1; 289-1; 595-1; and 1120-1; other ratios are available if required. The motor weighs 4½ lbs., has an overall length of 6-5/32" and a diameter of 3-21/64". The slow speed drive shaft is 5/16" in diameter.



These motors are used for instruments and control apparatus. For installations requiring precision of speed, the type NSY-12 synchronous motor provides an ideal power drive. Where precision of speed is not so essential, the type NSI-12 induction motor is used. All regular synchronous or induction types are furnished as capacitor start and run when required. Shaded pole unidirectional or reversible units, 4- or 8- poles, are also available in these frames.

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Constant Speed Generator with Governing Clutch

Electric Specialty Company

OPERATING at a constant speed, this machine when furnished as a self-excited a.c. generator, will deliver constant output voltage and frequency, even when driven from a source of power the speed of which is varying. It is particularly applicable to a.c. generators supplying power to sound amplifiers or talking moving picture equipment mounted on motor trucks, where it may be driven from the engine. The generator consists of a self-excited alternator, with d.c. windings for field excitation, which may also be used for charging the storage battery, if desired, and with a.c. windings delivering 60 cycles, a.c.

A special centrifugal clutch has been developed for driving these generators. Its working faces are covered with a special lining which has a constant coefficient of friction throughout a very wide range of activity.

The entire machine is furnished totally enclosed, with ribs on the clutch housing to dissipate the heat, and non-corrodible parts are used throughout. A "V" belt and pulleys of suitable size are usually used for the drive. The equipment is exceptionally durable.

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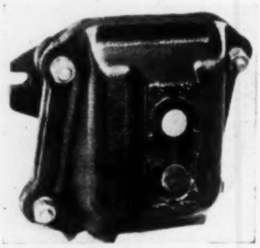
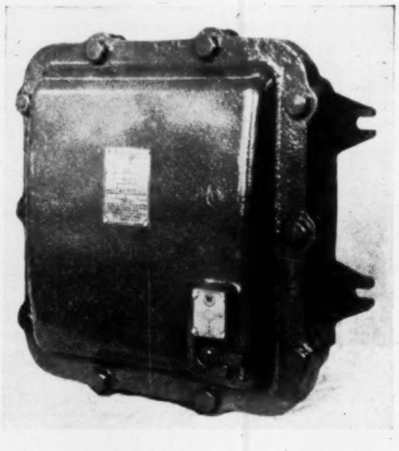
New Explosion-Resisting Linestarters

Westinghouse Electric and Mfg. Co.

DEVELOPED for use in Class I, Group D, hazardous locations as described in Art. 32, National Electric Code, these new explosion-resisting linestarters are designed for use in locations where highly flammable volatile liquids or gases are manufactured, used or handled—around oil refineries, dye plants, chemical plants, gasoline stations, etc. The starters consist of standard linestarter units mounted in heavy cast iron cabinets with wide flanges in accordance with Underwriters' specifications. The features of the standard starters—De-ion contactor, combination hand and automatic reset thermal overload relay—are incorporated. Both separate mounted pushbutton (small illustration) and built-in pushbutton types are available. Explosion-resisting pushbuttons for 2-wire control (low-voltage release) and for 3-wire control (low-voltage protection) are available.





Two New Models of the Snapon Controller

C. J. Tagliabue Mfg. Co.

THESE instruments were developed to meet the demand for moderately priced, yet sensitive and dependable temperature or pressure controllers. Among the applications are ice cream cabinets, water coolers, milk coolers, butcher boxes, florist display boxes, frozen foods and other similar uses.

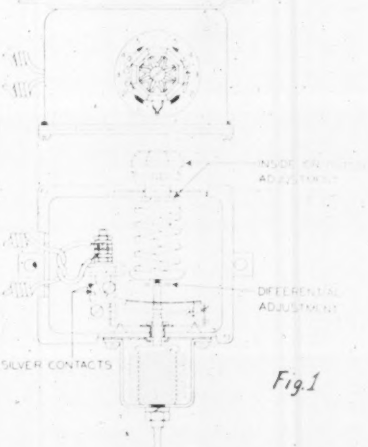


Fig. 1 shows a reverse-acting Type R-7 which *breaks* contact at the *low* temperature or pressure and *makes* contact at the high temperature or pressure. (The direct-acting does the opposite). This Type R-7 is made up in temperature model with a total range of 40° F.; minimum differential 4° and maximum as high as 25°. The pressure model has a total range of 40 lbs., part of which can be below atmospheric; minimum differential 4 lbs. and maximum up to 25 lbs.

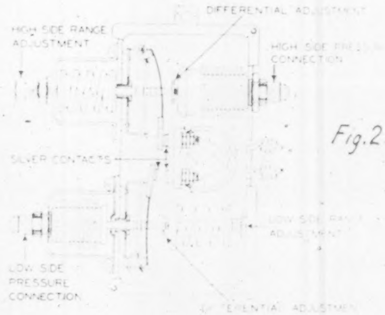


Fig. 2 shows a reverse-acting Type CS-5. Direct-acting also available (for operation see above) and this type can also be converted into a single-pole double-throw switch. Both the temperature model and the pressure model make possible a great variety of settings on both low and high sides by turning adjusting nuts up or down to raise or lower the temperature or pressure ranges. Similarly, differential settings are increased or decreased by revolving slotted nuts.

The instruments can be set at the factory in accordance with customer's specifications, but the simple adjusting mechanisms enable the service men to change easily either setting within the range of the controller by following the brief instructions pasted on the inside of the cover.

TAG Snapon Temperature and Pressure Controllers have been approved by Underwriters' Laboratories for use with 1½ h.p. motors a. c. 110 and 220 volts; 1 h.p. motors d. c. 110 volts, and ½ h.p. motors d.c. 220 volts, without relay.

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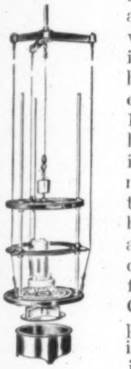
Galvanometer Suspension

G-M Laboratories, Inc.



EMBODYING many new refinements, this unit is designed to provide a stable means of support for instruments of the suspended mirror type for all kinds of measurements. It fills an urgent need among laboratories located in factories, along car tracks and railroads, or near buildings housing heavy engines and machinery. Even when attached to a ceiling which also supports heavy vibrating machinery, galvanometers of 1100 megohm sensitivity have a perfectly stable index line on a scale nine meters distant. Designed to facilitate rapid assembly, and with convenient adjustment to accommodate instruments of different sizes, the G-M Galvanometer Suspension provides utmost convenience. When correctly adjusted, vibrations transmitted to the supporting tripod travel down the three wires in phase and result only in a slight raising or lowering of the unit. The oil pan and vanes underneath the bottom plate in turn effectively damp vertical or lateral movements and prevent the suspension from being unduly affected by air currents or by touching the unit with the hands.

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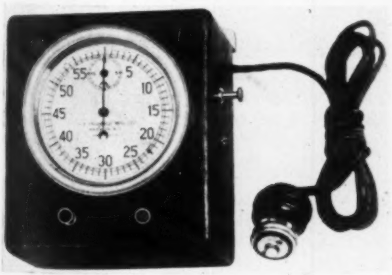
The TAG Electric Timer

C. J. Tagliabue Mfg. Co.

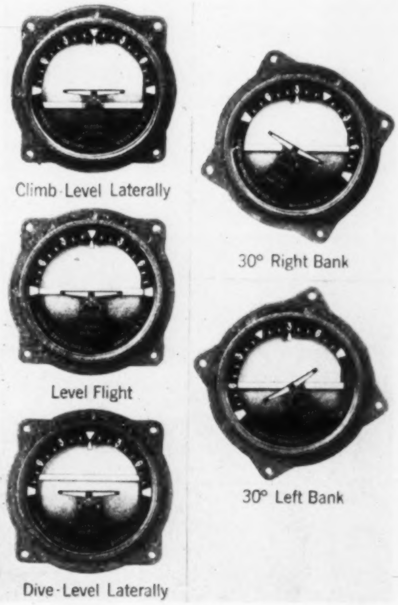
FOR timing viscosity determinations and other test intervals this new instrument, though costing little more than a good stop-watch, is said to be infinitely superior, being guaranteed accurate to 1/5 sec. for *any* time interval provided only that connection be made to 110-volt controlled 60 cycle a. c. The mahogany case is 5″ high and the dial 3″ in diam. Start, stop and throw-back features are conveniently placed, positive in action and operate with little effort. The synchronous motor is started and stopped instantaneously by a switch and mechanical brake.



The New Sperry Horizon

The Sperry Gyroscope Co., Inc.

THE new Gyro Horizon, in addition to simulating the natural horizon, showing the plane's position longitudinally and laterally when flying "blind," has the added feature of a Bank Indicator, the addition of which is considered most important, not only for accuracy in banking, but when climbing or diving "blind," as the plane can be kept perfectly level laterally. The new Horizon will be the same size as the present Horizon, but one pound lighter. The Sperry Company has spent many years in developing gyroscopic instruments to aid "blind" flying. The first gyroscopic Horizon and Directional Gyro were built by them in 1917.



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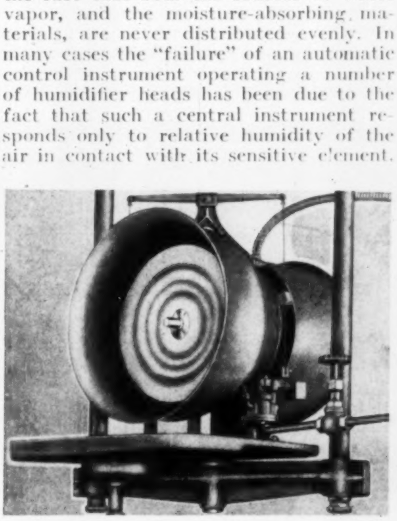
Combined Humidity Control and Humidifiers

Southworth Machine Co.

ONE of the problems met with in controlling the relative humidity of large workrooms arises from the fact that both the sources of water vapor, and the moisture-absorbing materials, are never distributed evenly. In many cases the "failure" of an automatic control instrument operating a number of humidifier heads has been due to the fact that such a central instrument responds only to relative humidity of the air in contact with its sensitive element.



No matter how excellent such an instrument may be, it cannot "feel" the variations in the different parts of the room.

This problem has been solved by combining an automatic humidity controller with each humidifier. The device recently brought out by the above company is a forced-draft centrifugal atomizer operated by a 1/5 h.p. Westinghouse motor and automatically turned on and off by a sensitive but durable ribbon of organic membrane. In operation, the device responds within two minutes to a 2% change in relative humidity, and of course more quickly to greater changes. It thus maintains the desired relative humidity within ± 2%. Its principal advantage, in addition to maintaining the desired condition throughout a large room, is economy—of water, of electricity and of depreciation. This is due to the fact that each unit operates only as needed. In a large workroom, for example, the row of humidifiers along an inside wall where it is cool would seldom be "on" and the row along a windowed wall facing south would supply the greater amount of vapor locally needed.

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Wind Measuring Station for Recording Wind Velocity and Direction

American Askania Corp.

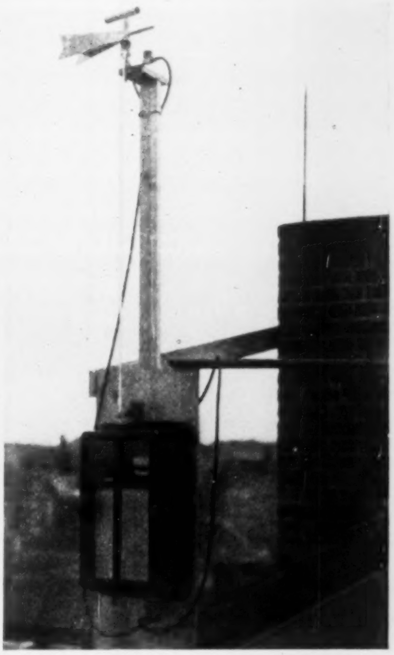
ONE of the most important tasks of the meteorologist in his investigations of the atmospheric structure, is to measure the direction and force of the wind. The Askania measuring station, noteworthy for the simplicity of its design and operation, enables fluctuations in the direction and velocity of the wind to be recorded with a high degree of accuracy. It consists of:

Weather vane with baffle nozzle.

Double recorder for recording wind velocity and direction.

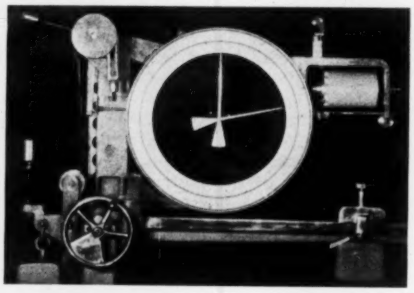
Rod connection between weather vane and recorder.

Pneumatic connections between pressure nozzle and velocity recorder.



New Self-Indicating Unit for Screw-Power Universal Testing Machines

Riehle Bros. Testing Machine Co.



To provide the many users of screw-power universal testing machines with the advantage of self-indication, a new unit has been placed on the market which can be quickly attached to any make or capacity screw-power machine now in use. It consists of a pendulum-actuated indicating needle traveling around the face of a dial graduated to the capacity of the machine. The pendulum itself is connected to the secondary beam of the machine by a steel ribbon attached to a special clevis which can be rapidly connected or disconnected, thus permitting a test either by the use of the self-indicating unit or by the micrometer dial screw beam. The device can be furnished with two scale ranges, and with or without an autographic recording apparatus.

The accuracy inherent in screw-power machines has heretofore been subject to the handicap of inexperienced or careless operation. This factor is eliminated by the use of the new self-indicating unit.

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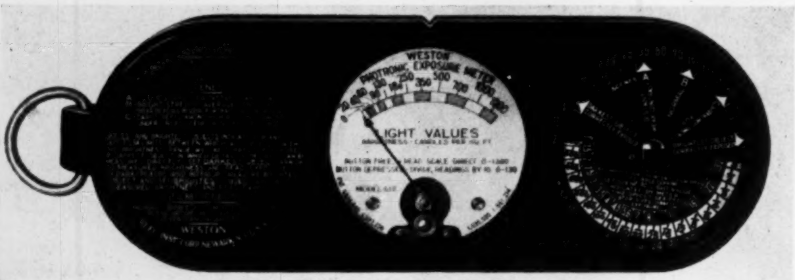
Universal Photographic Exposure Meter



Weston Electrical Instrument Corp.

By means of the Weston "Photronic" cell, light intensity is converted directly into electrical energy and measured directly in foot-candles with a properly scaled electrical instrument connected to the cell without the use of batteries or other auxiliaries. This characteristic of the Photronic cell has now been employed in a new instrument designed to measure the brightness of the field of view of a camera. This new instrument, the Universal Exposure Meter, consists of an electrical instrument connected to two Photronic cells and a very ingenious mechanical calculator all housed in a handsome black Bakelite case. The instrument reads from 0 to 1300 candles per sq. ft. Low values of brightness are measured by pressing a push button and dividing the indications by ten by omitting the last zero of the scale figures. The meter is very convenient to handle. It weighs 14 ounces and is 6½ inches long, 2¼ inches high and 1¼ inches thick.

The mechanical calculator translates the brightness measurements into proper apertures and shutter timings for any plate or film speed.

Directions: (1) Measure the average brightness of the scene being photographed by sighting through the notch on top of the meter toward the center of the scene and read its brightness as indicated on the instrument scale.

(2) Decide whether the scene is a normal one, a very distant one or one with dark and strong contrasts. Set the calculator for this scene selection to the light value just measured. The calculator is now set to give the proper combinations of aperture and shutter speed.

Now set the camera to correspond with these values.

Two other equally simple methods of determining exposure can be used if desired, that of measuring the light from the Darkest Object or from the Brightest Object in the scene and setting the calculator accordingly.

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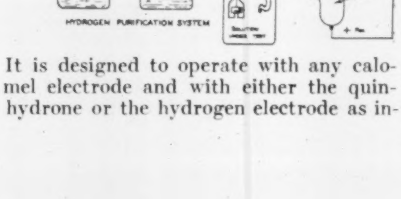
Self Calibrating Direct Reading Thermionic pH Instrument

Sensitive Research Instrument Corp.

Increased importance attached to hydrogen-ion measurement and control has developed a need for a simple deflecting pH meter. The Sensitive Research Thermionic pH Meter is completely self-contained and portable in the strictest sense, reads pH continuously and directly on a long legible scale (6½") and is equally satisfactory in the laboratory and for plant process control. It is self-calibrating to suit the particular set of electrodes and operating temperature encountered in plant operation.



It is designed to operate with any calomel electrode and with either the quinhydrone or the hydrogen electrode as indicator, and at any reasonable temperature. It may be left connected to the electrodes indefinitely without polarizing them.

The operation is simple: After it has once been adjusted to the electrode system selected and the temperature at which the electrodes are to operate, it is merely connected to the electrodes and the button pushed down or locked. The pH of the solution appears continuously upon the scale. The only attention required is occasional checking of the battery current.

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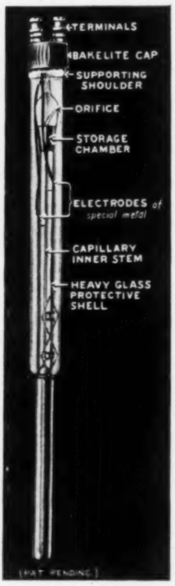
Mercury-in-Glass Temperature Regulator

Hiergesell Brothers

For automatically controlling the temperatures within oil baths, incubators and other suitable open vessels and enclosures, the modified Beckmann thermometer affords advantages among which the outstanding is the possibility of extremely close control.

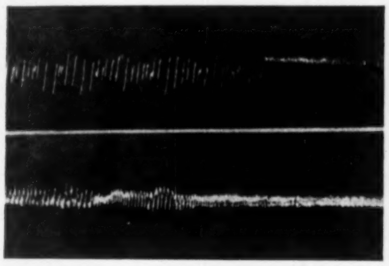


A common thermometer may be made to actuate a relay by fusing two wires in the capillary, but the setting point could not be raised or lowered. This shortcoming is done away with in the Beckmann thermometer, the working range of which can be transposed from one to another zone of the total range. This result is achieved by drawing off any desired length of mercury thread from the capillary to a surrounding reservoir, or vice versa. The Red Top Terminal Type Thermo-Regulator not only employs this principle but embodies modern features of design and construction which make unnecessary the skill previously required of users, and assure long service life for the instrument. It will control any desired temperature between 0 and 300° F. to plus or minus a tenth of a degree. Durable terminals end the risk of breakage which was present with the old style "pig tail" leads. A rugged outer glass shell protects the sensitive elements. Relays can be furnished in various types, housings and capacities.

The Scratch Extensometer

Baldwin-Southwark Corp.

HARDLY larger than a teaspoon, weighing less than an ounce, the Scratch Extensometer performs satisfactorily the service of instruments costing twenty times as much. It records tension-compression strains and, also, when tension-compression strain is present, will record shear strain. (A special adaptation can be made when pure shear strain alone is to be recorded.) It is readily fixed to members under load—by rubber bands, etc. The strain in the member under test causes a diamond to scratch a record on a steel target. Simultaneously the target moves at right angles both to the axis of the instrument and to the axis of the diamond. Hence, one coördinate of the record indicates strain while the other is availed of in order that a record may be had over a period of time more or less extended as fixed by the variability of the resultant transverse force and the amount and rate of strain variation. There is no motion of the target when there is no change of strain. Small changes in strain cause correspondingly small transverse movements of the target. Strains are evaluated from the record by a filar microscope, or the record may be photographed microscopically and the print measured directly.



An advantage is that no multiplying system is needed on *each* instrument. This largely accounts for the low price. One photomicroscope such as ordinarily used in metallography, or one filar microscope, suffices for the measurement of all targets. Targets may be filed away like correspondence.

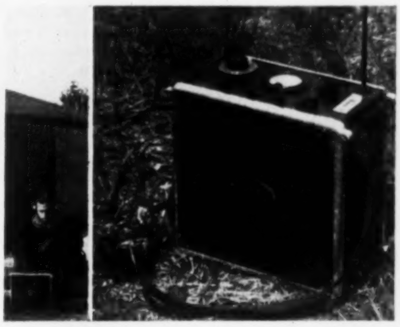
The lightness of the instrument coupled with the low price permits the application of many of these devices to a given structure for simultaneous determination of stresses. The field of the Scratch Extensometer is almost limitless. Wherever there is variation in strain, or where there are occasional large or small variations with intervening periods of inactivity, this instrument is definitely indicated.

Signal Strength Meter and Interference Locator

Tobe Deutschmann Corp.

DESIGNED in accordance with specifications of NELA, NEMA and RMA joint radio committee, this instrument combines the functions of an interference locator and a field intensity meter. It is so constructed that it may be used with equal facility in the trouble car or as a field instrument carried by the operator. It weighs only 28½ pounds fully equipped.

Electrical Characteristics. (1) The instrument is so constructed that both audible and visual indication of signal strength or noise level are obtainable. (2) It is sufficiently sensitive to provide full-scale meter deflection for any broadcast or interference signal reproduced by an a.c. operated receiver. (3) Tunable over the entire broadcast band. (4) Selectivity and fidelity comparable to those obtained in modern socket power operated receivers. (5) Capable of being operated with its own antenna or with the antenna and ground system of the receiver being affected by interference. (6) Provided with a ground terminal. (7) So shielded that a negligible output indication will be given when no antenna system is connected to the instrument. (8) Tube noise does not affect accuracy of readings. (9) Gain control allows continuous adjustment of output at all field strengths up to 10,000 microvolts per meter. (10) Suitable meter for checking filament and plate battery voltage. (11) Suitable control for adjusting filament voltage to the correct value.



In addition, when used to obtain a measurement of broadcast signal or interference field strength: (12) Signal generator capable of delivering sufficient energy to provide full scale output meter deflection over a reasonable range of field intensities and at all frequencies in the broadcast spectrum. (13) Provided with a properly designed attenuator system to adjust the signal generator output to the desired value. (14) So calibrated that signal strength readings may be obtained over a range of from one to ten thousand microvolts per meter.

◆ ◆ ◆

New Portable Tube Checker

Franklin Radio Corp.

IN the past, portable instruments checked tubes for the amplification constant by imposing a given a.c. signal voltage of the same magnitude to the grids under test. That method did not test the tube in accordance with the tube's characteristics, but assumed an arbitrary value. In the new FRC instruments, the plate, grid, and all parts requiring energizing voltages, are energized with d.c. voltages of various magnitudes, as governed by the characteristics of the tube. In other words, the same voltages are applied to the tube as when it is in use in a properly designed receiver with the tube manufacturer's recommended voltages applied thereto.

Provision is now made also for testing both the 2.5 and 6.3 volt series of six-prong tubes, as well as both the 2.5 and 6.3 volt series of seven-prong tubes to be announced this year. The seven-prong socket in the Franklin instrument is wired up and ready for the testing of these tubes.

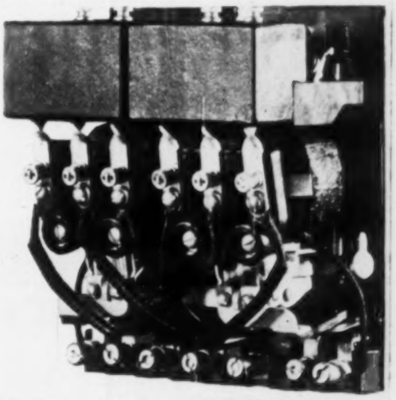
◆ ◆ ◆

Reversing Magnetic Contactors

Square D Company

A NEW three pole reversing magnetic contactor, interchangeable in rating and dimensions for a.c. and d.c. currents, has been developed by the Industrial Controller Division of this company. Maximum rating 3 h.p. The compact design, relatively small dimensions and convenient wiring arrangement make it adaptable for hoists, window and door control, dumb waiters, reversing machine tools, etc.

The contactors have a positive mechanical interlock and magnetic safety latches to prevent accidental closing. Arranged for either two-wire or three-wire control. The edgewise mounting of the movable contacts and the form of arc suppressors are a new principle of design for increasing the arc rupturing capacity. The contactors are mounted on a steel panel. These contactors are designated Class 8711 for a.c. and Class 7711 for d.c.



New Radio-frequency Bridge

General Radio Company

IN considering bridge circuits for radio frequencies it is the natural course to select simple circuits and those having similar elements permitting a symmetrical arrangement. While an elementary bridge circuit can be reasonably well balanced at 1000 cycles, at higher frequencies a double balance is necessary in order to eliminate all factors of stray capacitance. Two methods of accomplishing this offer themselves. One is the addition of a Wagner ground circuit by means of which the capacitances to ground are first balanced before obtaining a balance of the main bridge. A second arrangement is the substitution method which is, of course, extensively used in precision measurements at 1000 cycles.

In an endeavor to test out the practicability of bridge methods at radio frequencies, the above company has developed the Type 516-A Radio-Frequency Bridge. This is illustrated in Fig. 1 and the wiring diagram is shown in Fig. 2.

The entire bridge is enclosed in one shield, while separate internal shields enclose the ratio arms, the balance condenser, the power-factor balance resistor, and the output transformer. The latter also contains a shield between primary and secondary.

The shielded transformer is placed in the output of the bridge, so that at balance it will have no current in it and no external field. It is an air-core transformer with concentrated windings, whose capacitances to each other and to the shield have been minimized. By a suitable choice of the number of turns the band of frequencies between 10 kc. and 5 Mc. may be covered. The ratio arms are 100 ohms each. The balance condenser has a capacitance of 1000 $\mu\mu$f and is provided with a slow-motion friction drive. A small vernier condenser of 15 $\mu\mu$f allows the adjustment of the total capacitance to 0.01 $\mu\mu$f. The variable resistance for power-factor balance has three dials, tens and units decades, and a non-inductive slide wire having a total resistance of one ohm and reading to 0.01 ohm. The zero inductance of this 3-dial resistance unit is only 0.2 microhenrys and the maximum inductance 1.1 microhenry.

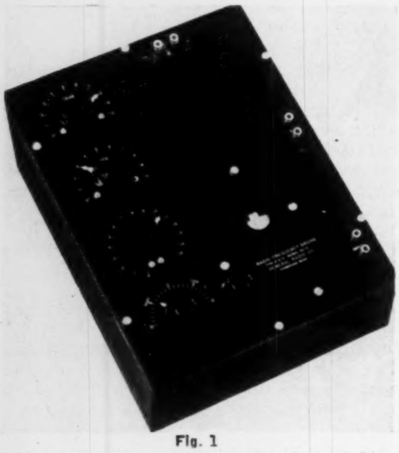


Fig. 1

The most available null detector in the broadcast range is a standard receiver of good sensitivity. Commercial superheterodyne receivers having a 10-microvolt sensitivity are entirely satisfactory. Using such a receiver at full sensitivity and merely listening to the loud-speaker, the bridge can be balanced to one part in 100,000 for capacitances of the order of 1000 $\mu\mu$f and to one part in 10,000 for resistances of the order of 100 ohms. These measurements were made in an unshielded room and there was noticeable outside pickup in the receiver.

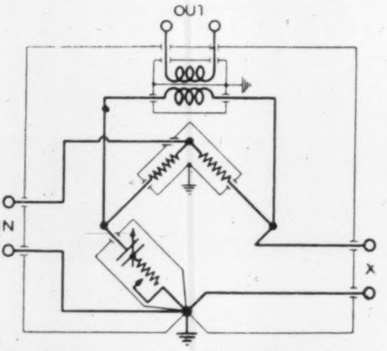


Fig. 2. Schematic diagram. The heavy lines represent the bridge elements, the light line the shields.

Measurements have been made with this bridge at a frequency of 1 Mc. by a substitution method, using an external Type 222 Precision Condenser and either the decade resistor in the bridge or a similar external one. The impedances measured have included the capacitance and resistance of air and mica condensers, varying from 100 $\mu\mu$f to 1000 $\mu\mu$f, the resistance and inductance of resistors varying from 1 to 10,000 ohms, and the resistance and reactance of an antenna whose natural frequency was 1.2 Mc. over the broadcast frequency range. The antenna measurements were interesting in showing that the voltages induced in fairly large antennae may approach a volt in magnitude. It is, therefore, desirable that the voltage applied to the bridge be at least of this magnitude and preferably larger, so that measurements may be made at all points.

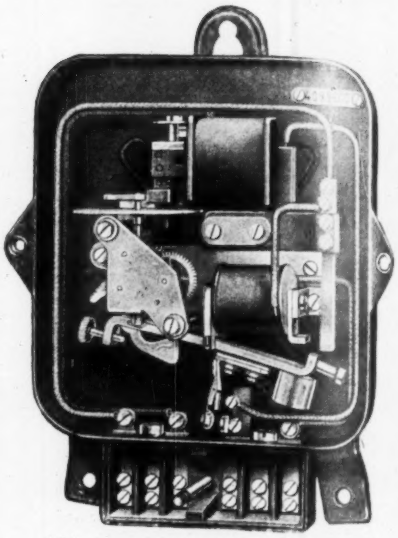
◆ ◆ ◆

Automatic Reset Timing Relay

Zenith Electric Co.

THIS unit, "TZE," is a new type of timer to replace dash pot, thermal and other types of devices for time delay and other uses. It consists principally of a small contactor which operates the main contact, and an adjustable speed induction disk motor. Contactor is controlled by momentary contact pilot circuit. When contactor coil is energized it closes main contacts, and engages a pawl and cam to a pinion gear driven by the motor. Induction motor is started when contactor closes. The motor rotates the pinion gear, which in turn, after the predetermined time, disengages the pawl and cam and permits the contacts to open by gravity. Timer is then instantly reset for next operation.

Minimum time of 15 seconds is obtained by operating motor at high speed, and disengaging cam, on rocker arm, from pinion gear. Time periods up to 3½ minutes are obtained by changing speed of motor. Longer time periods, up to 1 hour, are obtained by allowing cam to engage.



Adjustment:—Speed of motor is determined by position of pole piece in relation to laminated frame. This adjustment is effective by a screw. Cam is engaged or disengaged by means of a knurled screw.

Standard unit cannot be reset during its cycle of operation. By removing insulated screw at right of rocker arm, timer can be reset at any time by closing pilot circuit.

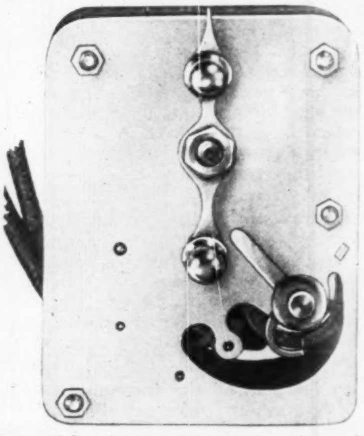
Type TZE can be used as basic unit with other timing devices for practically every required duty. It is 4" wide, 6" high and 2" deep. Capacity, 110-220 volts a.c. 25 to 60 cycles, 5 amps.

◆ ◆ ◆

Midget Interval Electric Timer

Walser Automatic Timer Co.

DESIGNED especially for use as standard equipment on electrical appliances where space is limited and a timing range from 1 to 45 minutes is desired, this compact device is only 1¾" wide, 2¼" high, 1½" deep with pointer for 1¾" dial scale calibration. It can be installed in a small wall outlet box with plenty of space to spare, but its construction and operating principles are the same as used in all senior models of Walser Timers. One operation of the pointer sets the time and closes the 6 amp. 110 volt switch circuit. After setting the pointer it can be reset or circuit can be opened by hand, if desired.



on stormy days, sometimes lighted after darkness equal to midnight has been reached. Some of the more populous districts are lighted by manually controlled substations rather than through astronomical clocks. The human eye, however, is a very poor judge of illumination intensity when the intensity varies slowly: we have found, by actual check, that the lights are likely to come on at any value from 30 foot-candles down to 0.5 foot-candle.

In most cities the lights, whether by human or clock control, are switched on and off in strict compliance with the street lighting contract. The city wants all the light it pays for and the Public Utility only cares to supply what is paid for. As a result the public sometimes receives plenty of light when it is not required and none when it is required.

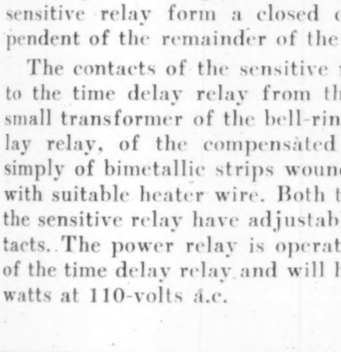
A photoelectric relay adjusted to operate at 5 foot-candles would, on the average, operate 10 to 15 minutes after sunset and 10 to 15 minutes before sunrise. Little or no power is saved, but the real gain is in that the light is supplied when needed. Simple logic dictates such a course.

Automatic Illumination Control

The device consists simply of a photoelectric light collector and a series of relays—a sensitive relay, a time delay relay and a power relay. The light collector is composed of three "photronic" cells connected in parallel and mounted in a waterproof housing. It is intended to be placed outdoors where it will receive unobstructed north sky light. Wire of any size and length is then run indoors to the sensitive relay. The adjustment of the relay is not affected by the resistance of the lead-in wires.

At an illumination intensity of 15 foot-candles approx. 50 micro-amperes is generated in the light collector and fed to the sensitive relay. This current is in no way affected by line voltage variation as the light collector and sensitive relay form a closed circuit electrically independent of the remainder of the circuits.

The contacts of the sensitive relay control the energy to the time delay relay from the low voltage side of a small transformer of the bell-ringing type. The time delay relay, of the compensated thermal type, consists simply of bimetallic strips wound for a low temperature with suitable heater wire. Both the time delay relay and the sensitive relay have adjustable platinum-iridium contacts. The power relay is operated through the contacts of the time delay relay and will handle a load up to 3000 watts at 110-volts a.c.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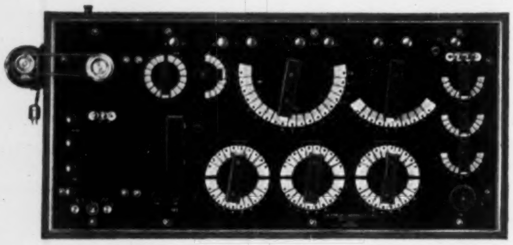

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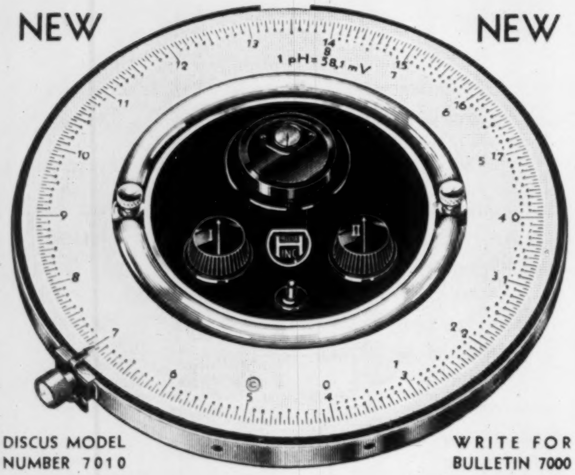

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Volume IX SEPTEMBER 1932 Number 9

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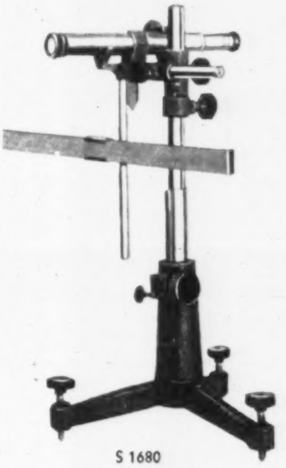

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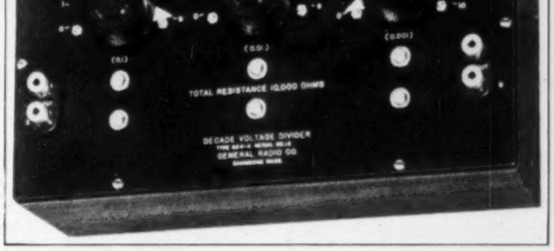

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Defender Automatic Regulator Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Voltage A.C.
Ward Leonard Elec. Co.
Water Level
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
COUNTERS—Ratchet, Magnetic
Veeder-Root, Inc.
Revolution
Baldwin-Southwark Corp.
Bristol Company
Brown Instrument Co.
Veeder-Root, Inc.
Stroke
Baldwin-Southwark Corp.
Bristol Company
COUPLING TRANSFORMERS
General Radio Company
CREEP TESTER
Baldwin-Southwark Corp.
Alfred Suter
CURRENT RECORDERS
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Tagliabue Mfg. Co., C. J.
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General Radio Co.
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Tagliabue Mfg. Co., C. J
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Baldwin-Southwark Corp
DEFORMETER (Beggs)
Baldwin-Southwark Corp.
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Gas
Foxboro Company
Electric
General Electric Co.
DIMMERS
Ward Leonard Elec. Co.
DIVIDING HEAD
Optical
Bausch & Lomb Optical Co
DIVIDING MACHINES
R. Y. Ferner Co.
Gaertner Scientific Corp.
DRAFT GAGES—see Gages
DYNAMIC BALANCING EQUIP,
Alfred Suter
DYNAMOMETERS
Weston Elec. Inst. Corp.
EARTH CURRENT METERS
Rawson Elec. Inst. Co.
EBULLIOMETERS
Tagliabue Mfg. Co., C. J.
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Baldwin-Southwark Corp.
ELECTRIC WAVE FILTER SECTIONS
General Radio Company
ELECTROMETERS
Rubicon Co.
ELECTRONIC METERS
Rawson Elec. Inst. Co.
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Baldwin-Southwark Corp.
ENGINE REVOLUTION COUNTERS
Veeder-Root, Inc.
EXTENSOMETER
Baldwin-Southwark Corp.
Alfred Suter
FATIGUE TESTERS
Baldwin-Southwark Corp.
Alfred Suter
FAULT FINDERS
General Radio Co.
Rubicon Company
Weston Elec. Inst. Corp.
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Ward Leonard Elec. Co.
FLASH & BURNING POINT TESTERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Indicating
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Defender Automatic Regulator Co
Morey & Jones, Ltd.
Indicating & Recording
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Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J
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Hays Corporation
FLUXMETERS
Rawson Electrical Instr. Co
FREQUENCY METERS
Indicating
General Electric Co.
Weston Elec. Inst. Corp.
Controlling
Recording
Bristol Company
Standards
General Radio Co.
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Burgess-Parr Co.
Defender Automatic Regulator Co
FUEL FLOW INDICATOR
Defender Automatic Regulator Co
Morey & Jones, Ltd.
FURNACE CONTROLS
Bailey Meter Co.
Bristol Company
Defender Automatic Regulator Co
Taylor Instrument Companies
FUSES
Instrument
Littelfuse Laboratories
GAGE RODS
Tagliabue Mfg. Co., C. J.
GAGES
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Amplifying
R. Y. Ferner Co.
Comparator
R. Y. Ferner Co.
Cylinder
R. Y. Ferner Co.
Deformation
Baldwin-Southwark Corp.
Depth
Dial
R. Y. Ferner Co.

Differential Pressure
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Hays Corporation
Morey & Jones, Ltd.
Tagliabue Mfg. Co., C. J.
Draft
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Hays Corporation
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Drill
Bausch & Lomb Optical Co.
Flow
Bailey Meter Co.
Morey & Jones, Ltd.
Grinding
Liquid Level
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Ellison Draft Gage Co.
Foxboro Co.
Morey & Jones, Ltd.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Loss of Head
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Morey & Jones, Ltd.
Pitch Diameter
R. Y. Ferner Co.
Pocket
Pressure
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Alfred Suter
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Pressure-Temperature
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Pressure & Vacuum
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Profile
Bausch & Lomb Optical Co.
Rain
Taylor Instrument Companies
Recording—Distance
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Strain
Baldwin-Southwark Corp.
Alfred Suter
Tester
Baldwin-Southwark Corp.
Thickness
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Vacuum
General Electric Co.
Volume
Brown Instrument Co.
Foxboro Co.
Water Level for Boilers
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Wind
Bristol Company
Brown Instrument Co.
Taylor Instrument Companies
GALVANOMETERS
Brown Instrument Co.
General Radio Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.
GAS ANALYTICAL METERS
Chemical
Hays Corporation
Tagliabue Mfg. Co., C. J.
Electrical
Brown Instrument Co.
GAS LEAK INDICATORS
Taylor Instrument Companies
GAS-METERS
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

GOVERNORS
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Bristol Company
Brown Instrument Co.
Tagliabue Mfg. Co., C. J.
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Tagliabue Mfg. Co., C. J.
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Burgess-Parr Co.
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Veeder-Root, Inc.
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Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Hellige, Inc.
HYDROGEN ION METERS
Indicating
Rubicon Company
HYDROMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
HYGROMETERS
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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IMPACT HARDNESS TESTER
Alfred Suter
IMPACT TESTING MACHINES
Alfred Suter
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Rubicon Company
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Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.
INSTRUMENT FUSES
Littelfuse Laboratories
INSTRUMENT TRANSFORMERS
General Electric Co.
Weston Elec. Inst. Corp.
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Rubicon Company
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Gaertner Scientific Corp.
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Rubicon Company
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Veeder-Root, Inc.
KILNBOY
Foxboro Co.
LABORATORY RHEOSTATS
Ward Leonard Elec. Co.
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Taylor Instrument Cos.
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Gaertner Scientific Corp.
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Centering
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Engineer's, Wye, Precision, Prism
R. Y. Ferner Co.
Taylor Instrument Companies
LOCOMOTIVE INDICATORS
Baldwin-Southwark Corp.

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MAGNETOMETERS
Rubicon Company
MANOMETERS
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Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Hays Corporation
Morey & Jones, Ltd.
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Gaertner Scientific Corp.
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Rubicon Company
MEGOHM VOLTMETERS
Weston Elec. Inst. Corp.
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Rawson Electrical Instrument Co.
Weston Elec. Inst. Corp.
MICROFARADMETERS
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Rubicon Company
Weston Elec. Inst. Corp.
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Gaertner Scientific Corp.
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Brinell
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Alfred Suter
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R. Y. Ferner Co.
Metallographic
Bausch & Lomb Optical Co.
Petrographical
Bausch & Lomb Optical Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
MICROTOMES
Bausch & Lomb Optical Co.
MILLIAMMETERS
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General Radio Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.
MILLIVOLTMETERS
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Brown Instrument Co.
General Electric Co.
Rawson Electrical Inst. Co.
Taylor Inst. Companies
Weston Elec. Inst. Corp.
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Hellige, Inc.
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Weston Elec. Inst. Corp.
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Bristol Company
Foxboro Co.
MOTOR STARTERS
Ward Leonard Elec. Co.
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Rawson Elec. Inst. Co.
MULTIPLE PEN RECORDER
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Foxboro Co.
MULTIPLIERS
Weston Elec. Inst. Corp.
OHM METERS
General Radio Co.
Rawson Elec. Inst. Co.
Rubicon Company
Weston Elec. Inst. Corp.

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Taylor Inst. Companies
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Foxboro Co.
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Defender Automatic Regulator Co.
Morey & Jones, Ltd.
Indicating & Recording
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
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Hays Corporation
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Weston Elec. Inst. Corp.
OSCILLOGRAPHS
Baldwin-Southwark Corp.
General Electric Co.
General Radio Co.
Hellige, Inc.
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Hays Corporation
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Gaertner Scientific Corp.
PERISCOPES
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
PERMEAMETERS
Rubicon Company
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General Electric Co.
Weston Elec. Inst. Corp.
PHOTO-ELECTRIC COLOR ANALYZERS
General Electric Co.
PHOTO-ELECTRIC COLOR COMPARATORS
General Electric Co.
PHOTOMETERS
Gaertner Scientific Corp.
Bausch & Lomb Optical Co.
PHOTO-MICROGRAPHIC EQUIP.
Bausch & Lomb Optical Co.
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Alfred Suter
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Defender Automatic Regulator Co.
Foxboro Co.
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Automatic Flow Record
Brown Instrument Co.
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Linear
Brown Inst. Co.
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Radial
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Bristol Company
Foxboro Co.
Square Root
Foxboro Company
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Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Hellige, Inc.
POSITION RECORDERS
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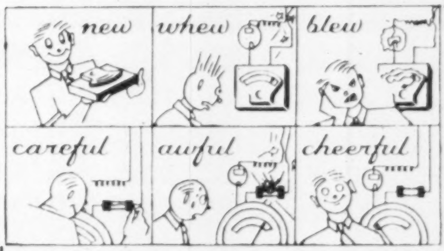
Foxboro Co.
Tagliabue Mfg. Co., C. J.



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Hellige, Inc.
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Foxboro Co.
Taylor Instrument Companies
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Brown Instrument Co.
Foxboro Co.
Taylor Instrument Companies
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Bristol Company
Brown Instrument Co.
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Taylor Instrument Companies
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Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
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Hellige, Inc.
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Veeder-Root, Inc.
SPEED INDICATORS
See Tachometers
SPEED RECORDERS
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SPEED REGULATORS
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Weston Elec. Inst. Corp.
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Baldwin-Southwark Corp.
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Veeder-Root, Inc.
Weston Elec. Inst. Corp.
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Brown Instrument Co.
TELEMETER
Baldwin-Southwark Corp.
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Gaertner Scientific Corp.

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Baldwin-Southwark Corp.
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Baldwin-Southwark Corp.
Alfred Suter
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Portable—Hardness
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Portable—Tensile—Compression
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Baldwin-Southwark Corp.
Universal
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Weston Elec. Inst. Corp.
THERMOPILE—Coblenta Type
Eppley Laboratory, Inc.
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Defender Automatic Regulator Co.
Foxboro Company
Tagliabue Mfg. Co., C. J.
Taylor Inst. Companies
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Defender Automatic Regulator Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
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Bristol Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Foxboro Co.
Vapor-Tension
Bristol Company
Brown Instrument Co.
Defender Automatic Reguiator Co.
Foxboro Co.
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Taylor Inst. Companies
Wet & Dry Bulb
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Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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TIME METERS
General Electric Co.
TIME OPERATION RECORDERS
Bristol Company
Foxboro Co.
Tagliabue Mfg. Co., C. J.
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Bristol Company
Brown Instrument Co.
Gaertner Scientific Corp.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
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Rawson Elec. Inst. Co.
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General Radio Co.
Weston Electrical Inst. Corp.
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Gaertner Scientific Corp.
Pocket
Taylor Instrument Companies

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Gaertner Scientific Corp.
Rubicon Company
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Hellige, Inc.
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Defender Automatic Regulator Co
Hays Corporation
Morey & Jones, Ltd.
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Bristol Company
Brown Instrument Co.
Defender Automatic Regulator Co
Foxboro Co.
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Taylor Instrument Cos.
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General Radio Company
VACUUM TUBE RELAYS
Burgess Laboratories, Inc., C. F
VACUUM TUBE VOLTMETERS
Rawson Elec. Inst. Co.
VALVES
Automatic Shut Off
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Brown Instrument Co.
Defender Automatic Regulator Co
Foxboro Company
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Taylor Instrument Cos.
Balanced
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Brown Instrument Co.
Defender Automatic Regulator Co
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Diaphragm
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Defender Automatic Regulator Co
Foxboro Company
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
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Bristol Company
Brown Instrument Co.
General Electric Co.
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Tagliabue Mfg. Co., C. J.
Regulating
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Bristol Co.
Brown Instrument Co.
Defender Automatic Regulator Co
Foxboro Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Safety, Fuel Shut-off
Tagliabue Mfg. Co., C. J
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Brown Instrument Co.
Foxboro Co.
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VIBROSCOPE
Baldwin-Southwark Corp.
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Taylor Inst. Companies
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General Radio Co.
Rubicon Company
Ward Leonard Elec. Co.
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General Electric Co.
Weston Elec. Inst. Corp.
VOLTMETERS
Electrostatic
Rawson Elec. Inst. Co.
Indicating
General Electric Co.
General Radio Co.
Rawson Electrical Inst. Co.
Weston Elec. Inst. Corp.
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General Electric Co.
Thermionic Rectifier
General Radio Co.
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Bailey Meter Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.
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General Electric Co.
WATTMETERS
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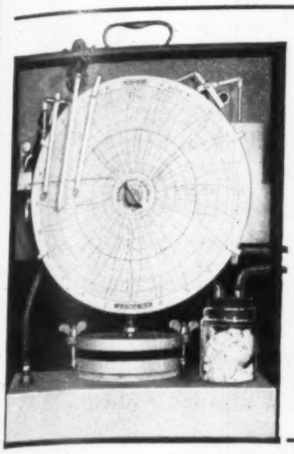
General Electric Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.
Recording
Bristol Company
General Electric Co.
WAVEMETERS
General Radio Co.
WAX MELTING APPARATUS
Tagliabue Mfg. Co., C. J.



DEFENDER : PORTABLE
Combustion Efficiency
RECORDER

A small Portable Instrument to record on 10" chart percent CO_2, Flue Gas Temperature and the Furnace Draft, on any make or type of High or Low pressure Boiler, with any type of Furnace, burning any type of Fuel.

This record allows you to determine by Flue Gas Analysis method the Combined Boiler and Furnace Efficiency; the pounds of air per pound of fuel used and the total and preventable loss of Fuel taking place, and we furnish the printed data tables to make these determinations by.

DEFENDER AUTOMATIC REGULATOR COMPANY
St. Louis, Mo.

The **R. Y. Ferner Co.,** Investment Bldg., Washington, D. C., American representatives of the Société Genevoise d'Instruments de Physique, of Geneva, Switzerland, announce the appointment as their local agents of H. S. Huncke & Co., 27 So. Jefferson St., Chicago (Neff, Kohlbusch and Bissell, of 2400 West Madison St. will continue to handle the sale of the Swiss jig borers as well as precision screw catting lathes and linear and circular dividing machine in this territory); in New York, Triplex Machine Tool Co.; in St. Louis, Blackman Hill Co., and in San Francisco, Joseph C. Fletcher. G. Robert Osgood, 128 Dexter St., Malden, Mass., A. Preston Petre, 608 Stewart Bldg., Baltimore; Galvin Machinery Sales Co., Brisbane Bldg., Buffalo; Pacific Machinery & Tool Steel Co., Portland, Oregon; A. M. Andrews, 2215 Leslie Ave., Detroit, Mich.

A manufacturing agreement has been concluded between **Riehle Bros. Testing Machine Company,** of Philadelphia, and The Torrington Manufacturing Company whereby the machines and instruments of the former company will be built by the latter at its plant in Torrington, Conn.

INSTRUMENTS EMPLOYMENT SERVICE

No charge for insertion of notices, which should be addressed to INSTRUMENTS Employment Service, 3619 Forbes Street, Pittsburgh, Pa., should be written tersely and must be received by the 25th of the month. In replying, put identification number on both envelope and letter..

MEN AVAILABLE

INSTRUMENT MAKER: 3½ years experimental laboratory of lamp company; 2 years experimental laboratory of electrical company. J-2.

PYROMETER MAN: Graduate Pennsylvania State College. Had charge of pyrometer calibration laboratory in plant with 1100 pyrometers. J-3.

ELECTRICAL ENGINEER: Graduate Charlottenburg Technische Hochschule; 8 years research engineer with chemical company; 4 years steel plant electrical engineer; can read German, French, Spanish and Italian. J-6.

INSTRUMENT SALESMAN: Mechanican Engineering Graduate; experienced sales and service most type of power plant instruments. District Sales Manager 5 years. Experience on gages, flow meter, CO_2 recorders, pyrometers and other testing equipment. J-8.

PYROMETER MAN: 8 years experience; expert electrician and gage (hydraulic, pressure, vacuum, etc.) service man; 3 years instrument laboratory; education equivalent two years of engineering college. J-9.

INSTRUMENT ENGINEER: Graduate Engineering College. Charge of instrument department in large industrial plant for 2½ years. J-10.

RADIO OPERATOR: Graduate Dodge Institute, 1917. Commercial license either broadcast or telegraph. J-12.

INSTRUMENT SALESMAN: Graduate M.E., 4 years control instruments, 2 years power plant specialties, 4 years manufacturing experience, in shop. Now N. Y. District Mgr. large rolling mill. J-13.

PHYSICIST: Ph.D. 1927. Experienced in electric and magnetic measurements, testing and research. J-14.

PRECISION INSTRUMENT MAKER: 28 years experience on scientific and geophysical instruments. J-15.

RADIO ENGINEER: Graduate University of Illinois; 2½ years experience in radio set circuit and tube measurements as well as development, design and patent investigation work. J-16.

ELECTRICAL METER and INSTRUMENT MAN: Technical graduate, 8 years in instrument laboratory of electrical manufacturing company. J-17.

INSTRUMENT ENGINEER: 2 years university, 5 years public utility, 2 years sales and service large recording and controlling instrument manufacturer. J-18.

INSTRUMENT MAKER: Engineering and Drafting instruments, 20 years shop experience, Master Degree Guild of Nuremburg. J-19.

ELECTRICAL ENGINEER: Graduate Purdue University. Experience with Telephone and Telegraph circuits, industrial control methods and equipment, and electrical instrument testing and maintenance. J-20.

AIRCRAFT INSTRUMENT MAINTENANCE ENGINEER: Formerly Service Engineer for largest manufacturer of aircraft instruments. Especially familiar with airplane instrument problems. J-21.

CHEMIST: Graduate Hunter College 1918. Spent twelve years working out various chemical processes in the laboratory and demonstrating them from a practical standpoint in paper mills. Work in the laboratory has included water analyses, some bacteriological work, fibre examination and testing of various materials. J-22.

ADVERTISING MANAGER: Also assistant sales manager of flow meter manufacturing company. M.I.T. graduate Mechanical Engineer with 10 years shop, engineering, advertising and sales experience. J-23.

PHYSICIST: 2 years experience in research with particular training in atomics and electronics. Have held two fellowships. J-24.

COMMUNICATION ENGINEER: 10 years practical experience in installation, operation and maintenance of high frequency transmitters and receivers, also land line practice. Knowledge of Spanish. J-25.

ELECTRICAL ENGINEER: Experience with electric meter manufacturer and with an electrical testing laboratory. Master's degree in electrical engineering. J-26.

SALES ENGINEER: Sales promotion work on scientific instruments, industrial control, etc. Three years experience with manufacturer of scientific instruments and three years experience with manufacturer of automatic regulating devices. Graduate of University of Chicago. J-27.

ELECTRICAL ENGINEER: Graduate of University of Illinois with experience in development of control apparatus desires connection in research, design, or development of instruments or control apparatus. J-28.

SALES ENGINEER: B.S. degree, 1931, and graduate work in Physics and Chemistry, sales experience. Desires permanent connection with instrument manufacturer with opportunity to enter sales department. J-29.

MECHANICAL AND CHEMICAL ENGINEER: College graduate, experienced in general machine shop work, drafting. Three years as second assistant engineer in merchant marine. J-30.

SALES ENGINEER: Experienced in shop, service and sales. Interested in handling unit heat, ventilation and air conditioning apparatus. Licensed professional engineer. J-31.

METER SPECIALIST: 20 years experience with utilities and manufacturers. Meter, distribution and sales department. College education. J-32.

INSTRUMENT SALESMAN: Selling experience covers flow meters, CO_2 recorders; draft recorders and indicators; combustion and draft control; water and oil meters; electrical recording meters; watthour meters; testing devices and megohmers. J-33

RESEARCH ENGINEER: Technical Director, Chemical Engineer, Research Chemist, expert in paper, oils, dyes, chemicals, fuels, augment and improve production, cut costs, sales service, patents, literary work, 6 languages. Trained Harvard and abroad. J-34

MECHANICAL ENGINEER: 11 years experience in design, construction, sale, and servicing of power plant and industrial metering, regulating and control equipment. J-35

AUTOMATIC MACHINE DESIGNER: 15 years designing experience on automatic machines including 5 years, on boiler instruments, testing instruments and telegraph instruments. J-36

INSTRUMENT ENGINEER: B. S. degree 1925; four years with precision electrical instrument company in the research department. Specialized in resistance coil manufacture and constant temperature baths J-37

PURCHASING AGENT: Experienced in purchasing materials for instrument manufacturers. Can systematize and fully qualified to take complete charge of department. J-39.

MEASUREMENT AND CONTROL SPECIALIST: Seeks connection with commercial laboratory, public utility or manufacturer, in capacity of developing engineer or consultant. Wide and extensive experience with all types of electrical instruments, both American and foreign, precision measurement, standardization and automatic control. Wide experience in patent work. Also adept in pyrometry and pneumatic control. Member A. I. E. E. J-40.

ELECTRICAL ENGINEER: 32, 3 years electrical metering and automatic control; 5 years laboratory and practical measurement of gas flow, furnace temperatures and gas analysis. Some sales experience. J-41.

RESEARCH ENGINEER: Graduate electrochemical engineer. Three years experience in industrial research and instrument development, both electrical and electrochemical. Specialized in gas analysis equipment. Machine shop experience. Research or teaching preferred. J-42.

INSTRUMENT SALESMAN: College trained, 5½ years inside, 8 years selling specialized in control applications, etc., for pulp, paper, lumber, milk, canning, power and refrigeration. J-43.

SALES ENGINEER: 4 years experience recording and control instruments. Graduate engineer, sales or engineering work desirable U.S.A. or Canada. J-44.

INSTRUMENT MECHANIC: Graduate Mech. Eng. Over 2 years field service with large Meter Co.; Experienced in combustion and use of Orsat. J-45.

INSTRUMENT SPECIALIST: College trained. 3 years in a standardizing laboratory; 2 years with manufacturer of temperature recording and controlling instruments; 2 years' experience in repairing, checking and installation of all types of temperature controlling and recording instruments. J-46.

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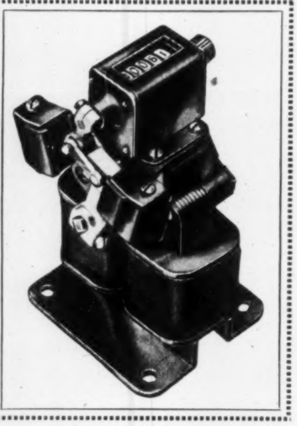

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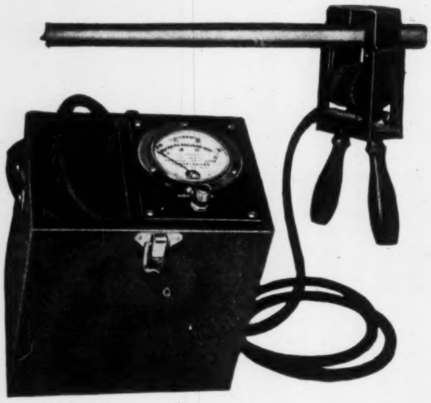

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